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ROYAL COMMISSION ON SEWAGE DISPOSAL.

SIXTH REPORT

OF

THE COMMISSIONERS

APPOINTED TO INQUIRE AND REPORT WHAT METHODS OF

Treating and Disposing of Sewage

(Including any Liquid from any Factory or Manufacturing Process)

MAY PROPERLY BE ADOPTED.

DISPOSAL OF LIQUID REFUSE FROM DISTILLERIES.

Presented to both Houses of Parliament by Command of His Majesty.

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VICTORIA R.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith: To Our Right Trusty and Right Well-beloved Cousin, Walter Stafford, Earl of Iddesleigh, Companion of Our Most Honourable Order of the Bath; Our Trusty and Well-beloved Sir Richard Thorne Thorne, Knight Commander of Our Most Honourable Order of the Bath, Medical Officer of the Local Government Board; Our Trusty and Well-beloved Constantine Phipps Carey, Esquire, Lieutenant-Colonel and Honorary Major-General on the Retired List of Our Army; Our Trusty and Well-beloved Charles Philip Cotton, Esquire; Our Trusty and Well-beloved Michael Foster, Esquire, Master of Arts, Professor of Physiology in Our University of Cambridge; Our Trusty and Well-beloved Thomas Walter Harding, Esquire, Retired Lieutenant-Colonel of Our Auxiliary Forces, with Honorary Rank of Colonel; Our Trusty and Well-beloved Thomas William Killick, Esquire; Our Trusty and Well-beloved William Ramsay, Esquire, Professor of Chemistry, University College, London; and Our Trusty and Well-beloved James Burn Russell, Esquire, Doctor of Medicine, Master of Surgery: Greeting!

Whereas We have deemed it expedient that a Commission should forthwith issue to inquire and report:

1. (1) What method or methods of treating and disposing of sewage (including any liquid from any factory, or manufacturing process) may properly be adopted, consistently with due regard for the requirements of the existing law, for the protection of the public health, and for the economical and efficient discharge of the duties of local authorities; and

   (2) If more than one method may be so adopted, by what rules, in relation to the nature or volume of sewage, or the population to be served, or other varying circumstances or requirements, should the particular method of treatment and disposal to be adopted be determined; and

2. To make any recommendations which may be deemed desirable with reference to the treatment and disposal of sewage;

Now know ye, that We, reposing great trust and confidence in your knowledge and ability, have authorised and appointed, and do by these Presents authorise and appoint, you, the said Walter Stafford, Earl of Iddesleigh, Sir Richard Thorne Thorne, Constantine Phipps Carey, Charles Philip Cotton, Michael Foster, Thomas Walter Harding, Thomas William Killick, William Ramsay, and James Burn Russell to be Our Commissioners for the purposes of the said Inquiry.

And, for the better effecting the purposes of this, Our Commission, We do by these Presents give and grant unto you, or any three or more of you, full power to call before you such persons as you shall judge likely to afford you any information upon the subject of this Our Commission; and also to call for, have access to, and examine all such books, documents, registers, and records as may afford you the fullest information on the subject, and to inquire of and concerning the premises by all other lawful ways and means whatsoever.

And We do by these Presents authorise and empower you, or any three or more of you, to visit and personally inspect such places as you may deem it expedient so to inspect for the more effectual carrying out of the purposes aforesaid.

6225—VI. 5,000—Wt. 9302. 2/09. Wy. & S. 3562r.

And We do further by these Presents will and ordain that this Our Commission shall continue in full force and virtue, and that you, Our said Commissioners, or any three or more of you, may from time to time proceed in the execution thereof, and of every matter and thing therein contained, although the same be not continued from time to time by adjournment.

And We do further ordain that you, or any three or more of you, have liberty to report your proceedings under this Our Commission from time to time, if you shall judge it expedient so to do.

And Our further Will and Pleasure is that you do, with as little delay as possible, report to Us, under your hands and seals, or under the hands and seals of any three or more of you, your opinion upon the matters herein submitted for your consideration.

And for the purpose of aiding you in such matters, We hereby appoint Our Trusty and Well-beloved Frederick James Willis, Esquire, to be Secretary to this Our Commission.

Given at Our Court at St. James's, the Seventh day
of May, One thousand eight hundred and ninety-eight,
in the Sixty-first Year of Our Reign.

By Her Majesty's Command,
(Signed) M. W. Ridley.

William Henry Power, Esq., F.R.S.,
To be a Member of the Royal Commission on Sewage Disposal.

VICTORIA R.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith: To Our Right Trusty and Well-beloved William Henry Power, Esquire, Fellow of the Royal Society, Medical Officer of the Local Government Board: Greeting!

Whereas We did, by Warrant under Our Royal Sign Manual, bearing date the Seventh day of May, One thousand eight hundred and ninety-eight, appoint Our Right Trusty and Right Well-beloved cousin Walter Stafford, Earl of Iddesleigh, Companion of Our Most Honourable Order of the Bath, together with the several Gentlemen therein mentioned, or any three or more of them, to inquire into the treatment and disposal of sewage.

And whereas One of the Commissioners so appointed, namely, Sir Richard Thorne Thorne, has since deceased.

Now know Ye, that We, reposing great confidence in you, do, by these Presents, appoint you, the said William Henry Power, to be one of Our Commissioners for the purpose aforesaid, in the room of the said Sir Richard Thorne Thorne, deceased, in addition to, and together with, the other Commissioners whom we have already appointed.

Given at our Court at Saint James's, the Seventh
day of February, One thousand nine hundred, in the
Sixty-third Year of Our Reign.

By Her Majesty's Command,
(Signed) M. W. Ridley.

Whitehall, March 18th, 1901.

The King has been pleased to issue a Commission, under His Majesty's Royal Sign Manual, to the following effect:—

EDWARD R.

Edward the Seventh, by the Grace of God, of the United Kingdom of Great Britain and Ireland King, Defender of the Faith, to all to whom these Presents shall come, Greeting!

Whereas it pleased Her late Majesty from time to time to issue Royal Commissions of Inquiry for various purposes therein specified:

And whereas in the case of certain of these Commissions, namely, those known as—

The Historical Manuscripts Commission;
The Horse Breeding Commission;
The Local Taxation Commission;
The Port of London Commission;
The Salmon Fisheries Commission; and
The Sewage Disposal Commission;

the Commissioners appointed by Her late Majesty, or such of them as were then acting as Commissioners, were, at the late demise of the Crown, still engaged upon the business entrusted to them:

And whereas We deem it expedient that the said Commissioners should continue their labours in connection with the said enquiries notwithstanding the late demise of the Crown:

Now know Ye, that We, reposing great trust and confidence in the zeal, discretion, and ability of the present members of each of the said Commissions, do by these Presents authorise them to continue their labours, and do hereby in every essential particular ratify and confirm the terms of the said several Commissions.

And We do further ordain that the said Commissions do report to Us under their hands and seals, or under the hands and seals of such of their number as may be specified in the said Commissions respectively, their opinion upon the matters presented for their consideration; and that any proceedings which they or any of them may have taken under and in pursuance of the said Commissions since the late demise of the Crown, and before the issue of these Presents shall be deemed and adjudged to have been taken under and in virtue of this Our Commission.

Given at Our Court at Saint James's, the fourth
day of March, One thousand nine hundred and one,
in the First Year of Our Reign.

By His Majesty's Command,
(Signed) Chas. T. Ritchie.

THOMAS JOSEPH STAFFORD, F.R.C.S.I.,

To be a Member of the Royal Commission on Sewage Disposal.

EDWARD R.

Edward the Seventh, by the Grace of God, of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas King, Defender of the Faith, To Our Trusty and Well-beloved Thomas Joseph Stafford, Esquire, Fellow of the Royal College of Surgeons of Ireland, Medical Commissioner of the Local Government Board for Ireland: Greeting!

Whereas Her late Majesty Queen Victoria did by Warrant under the Royal Sign Manual bearing date the Seventh Day of May One thousand eight hundred and ninety-eight, appoint Our Right Trusty and Right Well-beloved Cousin, Walter Stafford, Earl of Iddesleigh, Companion of Our Most Honourable Order of the Bath, together with the several Gentlemen therein mentioned, to be Commissioners to inquire into the treatment and disposal of Sewage.

And whereas one of the Commissioners so appointed, namely, Our Trusty and Well-beloved Charles Philip Cotton, Esquire, hath humbly tendered unto Us his resignation of his appointment as one of the said Commissioners:

Now know Ye, that We, reposing great confidence in you, do by these Presents appoint you, the said Thomas Joseph Stafford, to be one of Our Commissioners for the purpose aforesaid, in the room of the said Charles Philip Cotton, resigned, in addition to and together with the present Members of the Commission.

Given at Our Court at Saint James's, the Seventh day of May, One thousand nine hundred and two, in the Second Year of Our Reign.

By His Majesty's Command.
(Signed) CHAS. T. RITCHIE.

REGINALD ARTHUR TATTON, ESQUIRE,

To be a Member of the Royal Commission on Sewage Disposal.

EDWARD R & I.

Edward the Seventh, by the Grace of God, of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas King, Defender of the Faith, To Our Trusty and Well-beloved Reginald Arthur Tatton, Esquire, Greeting!

Whereas Her late Majesty Queen Victoria did by Warrant under the Royal Sign Manual bearing date the Seventh Day of May, One thousand eight hundred and ninety-eight, appoint Commissioners to inquire into the treatment and disposal of Sewage.

And whereas a vacancy has been caused in the body of the Commissioners appointed as aforesaid by the death of Major-General Constantine Phipps Carey, C.B.

Now know Ye, that We, reposing great confidence in you, do by these Presents appoint you, the said Reginald Arthur Tatton, to be one of Our Commissioners for the purpose aforesaid, in the room of the said Constantine Phipps Carey, deceased, in addition to and together with the present Members of the Commission.

Given at Our Court at Saint James's, the Seventh day of January, One thousand nine hundred and seven, in the Sixth Year of Our Reign.

By His Majesty's Command.
(Signed) H. J. GLADSTONE.

SIXTH REPORT.

To The King's Most Excellent Majesty:

May it please Your Majesty,—

We, Your Commissioners, appointed to inquire into the methods of disposing of sewage and trade effluents, humbly submit this Report concerning the disposal of the liquid refuse from distilleries.

I. INTRODUCTORY.

1. The difficulties connected with the purification of the refuse from distilleries were first brought to our notice by our colleague the late Dr. J. Burn Russell, a member of the Local Government Board for Scotland, and in May 1903, on the occasion of a visit to Scotland for the purpose of inspecting the Glasgow Sewage Works, we visited a number of malt distilleries in the north of Scotland.

As a result of our preliminary investigations we were satisfied that the treatment of distillery refuse was a particularly difficult problem, and also one of some urgency, but other work prevented us from commencing any experimental investigation of the subject at that time.

2. In February 1904, at the request of associations representing the Scottish malt distilling industry, we received a deputation consisting of Dr. Cowie, Mr. Allan, Mr. Thorne, Mr. Hopkins, Mr. James Robertson, Mr. Doig, Mr. Grant (Glen Grant), Mr. Fergusson (Jura), Mr. Brown (Campbeltown), and Mr. Mustard.

The evidence of these witnesses was published in Appendix I. of our last Report (Cd. 4279).

As showing the magnitude of the interests involved, we were informed that during the year 1902, the output from the distilleries which they were representing "was over 29,000,000 gallons, representing about £15,000,000 sterling in Imperial revenue per annum." Cowie, 19736.

3. These witnesses represented to us that in consequence of actions in the Courts, and the attitude of the riparian owners, the manufacturers were at a loss to know what to do.

They stated that they were quite willing to spend money on works of purification, if they could be satisfied that meanwhile they would not be unreasonably attacked by riparian proprietors. But these gentlemen, they said, seemed to demand that the refuse should be converted into absolutely pure water or into a liquid of composition identical with that of the river, and it was not possible to comply with demands such as these. Cowie, 19889.

4. The distillers requested that we would investigate the subject "with the view of fixing some standard of purity up to which it would be safe for the riparian proprietors to receive effluents from distilleries into the stream" and of reporting on the various methods of disposing of distillery refuse.

They also urged that the recommendations contained in our third Report as to the setting up of a central authority to determine questions as to river pollution and other matters should be extended to Scotland.

Dr. Cowie, who was the chief witness, summed up the request of the manufacturers as follows:

19736.

> "I wish to impress upon the Commission that we distillers do not want in any way to injure the streams or to encroach on the rights of the riparian owners; we only ask reasonable facilities for carrying on our business, and we are in hopes that an interview between you and the riparian owners will bring into proper perspective our respective positions, and convince them that their interests are not being unduly encroached upon by us, and that there must be a little give and take between us before a settlement can be effected. In what I have said with regard to the Spey—you have been hearing so much about it—I have spoken from my own point of view; the other gentlemen can speak for theirs, but I may say the question is acute all over Scotland, and they will be able to tell you so. Well, there are four points that we wish to urge upon you. First, that you may send your scientific staff up to investigate the methods in operation, and to give an opinion as to what is the best possible means of purification of our effluents and to establish some standard of purity. Second, that you urge upon the Government to promote legislation whereby upon application to a local authority manufacturers may compulsorily obtain land for purification works at a reasonable figure. Third, that you extend the recommendations in your third Report to Scotland, so that the interests of the manufacturers as well as those of the landlords may be safeguarded by the appointment of a central authority. Fourth, we venture to suggest that you ask the Duke of Richmond and Gordon, Mr. Menzies of Arndilly, Mr. Findlay of Aberlour, and Mr. Grant of Elchies, and other proprietors to exchange views with you in order that some arrangement may be arrived at until such time as you can report."

5. In May, of the same year, at our invitation, the Duke of Richmond and Gordon, Mr. John R. Findlay, Mr. W. S. Menzies and Mr. J. H. W. Grant attended before us, as representatives of the riparian proprietors in the district of the Spey and Fiddich, which is one of the most important districts of the malt distilling industry.

19929. These witnesses drew attention to the fact that the number of distilleries in the district of the Spey and Fiddich had increased considerably during the previous ten or twelve years, and that the pollution of these rivers had become very serious. The Duke stated that in the spring time the Fiddich, a tributary of the Spey, was reduced to a "condition of absolute filth" with "slime and fungus through it from side to side," and that "there was not one fish in the Fiddich now to fifty that were there ten years ago."

19930. He also stated that the same condition prevailed on the "Spey beds." In the opinion of the proprietors the salmon fisheries would be very prejudicially affected unless the pollution were stopped.

19934. They considered that they had been patient beyond words in their dealings with the distillers; they had never threatened them needlessly, and they had only had recourse to the Courts when matters had become so serious that this step was necessary for the protection of their property.

19996.
19990.
19972.
20044.

6. As regards the amount of purification which the proprietors required, the Duke seemed to suggest that 100 per cent., or absolute purification, was necessary, while Mr. J. H. W. Grant put it that, at common law, he was entitled to require that the water should be passed on by the distiller in its original state.

7. We suggested that inasmuch as a large number of experiments were in progress, and the distillers seemed anxious to find out in what way the refuse could be properly purified or disposed of, perhaps the proprietors would be willing not to press matters to extreme lengths until we had reported, provided the distillers adopted all practicable temporary measures to diminish the evil effects of pollution.

20059–20070. In regard to this suggestion the Duke stated that he was not able on behalf of the proprietors to give any pledge, but he submitted that they had not been unreasonable in the past and that he thought they might be trusted to be not unreasonable in the future.

19990.
19996.
20001.

8. The Duke informed us that the riparian proprietors were opposed to the proposal that questions of pollution should be determined by a Central Department, and that they preferred to leave the matter to the ordinary Courts of Law.

9. In the following year (1905) we decided to undertake an experimental investigation, and arrangements were made to visit Scotland for the purpose of discussing with the proprietors and distillers the lines on which the investigation should proceed.

But ultimately the proprietors decided not to attend, and the conference took place with the distillers alone.

10. After considering the suggestions made by the distillers we decided to investigate the question of standards for distillery effluents. We also decided that the processes which were in operation for the disposal of the waste liquids should be critically examined.

These comprised :—

(*a*) Purification on land ;

(*b*) Destruction by heat ;

(*c*) Evaporation followed by torrefaction with a view to the production of a marketable manure ; and

(*d*) Purification by means of contact beds.

11. Our preliminary investigations, together with the results of some laboratory experiments which were carried out by our chemist, Dr. McGowan, led us to doubt whether the treatment of distillery refuse by the contact beds which had been erected was likely to be satisfactory, and at our suggestion a modified purification plant was erected at the Coleburn Distillery. The cost of this plant was defrayed by certain members of the North of Scotland Malt Distillers' Association.

Similar experiments to those of Dr. McGowan had previously been carried out by Professor Hendrick.

Our thanks are due to Messrs. J. R. Robertson & Son, Ltd., the proprietors of the Coleburn Distillery, and in particular to Mr. W. Brown Robertson, Junr., for the assistance which they have rendered to us in connection with the Coleburn experiments.

We also wish to express our indebtedness to Dr. Cowie, the proprietor of the Mortlach Distillery, Dufftown, for his valuable help throughout our inquiry. The experiments which Dr. Cowie himself carried out, before our investigations commenced, have been of great assistance in enabling us to ascertain how the refuse liquids from a malt distillery may be satisfactorily purified by means of filters.

12. For the purpose of our investigations we appointed Mr. R. D. Littlefield, F.I.C., to act as resident chemist, and the experiments at Coleburn were placed under his charge. He acted throughout under the guidance of Dr. McGowan and Mr. Colin C. Frye, our chemists in London. The necessary chemical analyses, etc., were made partly at Coleburn by Mr. Littlefield and partly at Ealing by Dr. McGowan. The bacteriological analyses were made by Dr. A. C. Houston. Mr. G. B. Kershaw, our engineer, also advised upon points of construction and engineering. We also directed Mr. Littlefield to visit other distilleries from time to time for the purpose of obtaining information as to the working of various methods of dealing with the waste liquids.

We have ourselves inspected the works from time to time.

The following papers are presented as Appendices to this Report :—

(I.) A memorandum by Dr. McGowan on some preliminary laboratory experiments.

(II.) A Report by Mr. Littlefield in regard to his observations.

(III.) A memorandum by Dr. McGowan on the working of the Coleburn filters and the Mortlach contact beds, and on the results obtained from them.

(IV.) A Report by Mr. Calderwood, the Inspector of Salmon Fisheries for Scotland, and Mr. Littlefield, on experiments carried out at Coleburn Distillery in order to test the effects, upon Salmon ova and Salmon fry, of the effluent obtained from the purification process which was suggested by us.

(V.) Tables of Analyses.

(VI.) A report by Mr. Stevenson Macadam, F.I.C., F.C.S., to the Riparian Proprietors on the River Spey, with reference to the experiments at Coleburn.

II. SOME OBSERVATIONS ON THE PROCESSES INVOLVED IN THE PRODUCTION OF WHISKY FROM MALT.

13. Briefly, the manufacture of whisky comprises the following operations :—

(1) The production of malt from barley.
(2) Drying and grinding the malt.
(3) Mashing the malt.
(4) Fermenting the wort with yeast.
(5) Distilling the "wash".
(6) Distilling the "low wines."

From most of these operations there is produced a residual liquid of a more or less polluting nature.

Malting the Barley.

14. In this operation the barley is steeped in water in order to clean and soften it, so that when removed to the malting floors it may germinate. Two methods of steeping are in use. In one the barley is allowed to soak in tanks in two or three successive lots of water for a total period of about sixty hours; in the other water is allowed to flow into and out of the tank containing the barley for the same length of time. By the former method the waste steep water which is produced is highly charged with organic matter—the first portion of it especially being a very foul smelling and polluting liquid. In continuous steeping the waste steep liquor is organically weaker, but there is necessarily a much larger volume of it. By the first method about eight to ten gallons of waste steep water are produced for each bushel of barley soaked. No records are available as to the quantity of waste steep water produced by continuous steeping, but probably 30 to 40 gallons per bushel of barley would be approximately correct. It is a grey or brown foul-smelling liquid and it contains the dirt, dust, and grit which were mixed with the barley, together with certain soluble mineral salts and organic bodies and colouring matter from the barley husks. The following are typical analyses of steep waters produced by the two methods :—

	Continuous process.	Quiescent soaking.
	Parts per 100,000.	Parts per 100,000.
Ammoniacal Nitrogen	0·13	0·58
Albuminoid Nitrogen	0·45	2·24
Oxygen absorbed in 4 hours from $\frac{N}{8}$ Permanganate at 27° C.	30·00	86·00
Dissolved oxygen taken up from water for complete oxidation	(say) 260*	(say) 700–800*

* These are estimates based on the analysis of a limed steep water.

Drying and grinding the Malt.

15. This operation does not produce any polluting liquid.

Mashing the Malt.

16. "Mashing" consists of extracting the saccharine and other soluble matter from the ground malt by means of hot water. The "mash tun" and "tun room" must be kept scrupulously clean and large quantities of water are used for the purpose. These washings constitute part of the general wash-water from the distillery—they vary greatly in organic strength but must always be regarded as polluting liquids.

In addition, the drainings from the "wet draff," that is, grains left after the extraction of the malt, are organic and polluting. The amount of these drainings is not, however, usually large.

Fermenting the wort, i.e., *the cooled malt extract, with yeast.*

17. In this operation a large quantity of wash-water is produced, owing to the fact that the "backs" or vessels in which the fermentation takes place must also be kept scrupulously clean. This wash water, of which there may be from 20,000 to 40,000 gallons per week according to size of distillery, contains a good deal of lime—lime being used in cleansing the "backs"—together with soluble and insoluble organic matter, *e.g.*, yeast cells. It is a polluting liquid, though not so polluting as steep water.

Distilling the "wash."

18. It is from this operation that the chief polluting waste liquor is derived. When the "wash" has fermented to the correct degree—that is, when the sugar has been converted into alcohol—the whole contents of the wash-back, or fermenting vessel, are run into the wash charger and then into the still. The alcohol and other volatile matters are distilled off and condensed for subsequent re-distillation.

There remains in the still the "burnt ale," or "pot ale" as it is called. This residue is a heavy brown turbid liquid, smelling something like beer. Pot ale in its fresh state is not unpleasant, but it rapidly putrifies. It contains some of the mineral salts of the barley, together with much extractive matter and burst yeast cells. The amount of pot ale produced is very considerable, being from 12 to 14 gallons per bushel of barley malted. The following are two more or less typical analyses of burnt ale:—

	Parts per 100,000.	
Ammoniacal nitrogen	3·82	12·16
Albuminoid nitrogen	60·40	—
Total organic nitrogen	—	156·9
Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C. at once	—	109·2
Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C. in 4 hours	1,177·8	1,181·0
Phosphate as phosphoric anhydride	198·0	—
Dissolved oxygen taken up from water for complete oxidation	—	4,573

Distilling the "low wines."

19. The distillation of the low wines, *i.e.*, of the alcoholic distillate from the first still, may be regarded as a refining process. The residue in the second still, which is called spent lees, is nothing like so polluting as the pot ale, nor is there so much of it. It contains saline and earthy matter and volatile and organic matter in about equal proportions—say 15 to 18 parts per 100,000 of each—a small amount of volatile acid, chiefly acetic, and generally traces of copper dissolved from the still.

Wash Waters.

20. In this item must be included all the water used in washing out the distillery each week. The steep tanks, fermenting vessels, stills, floors, and in fact all the apparatus at a distillery must be kept perfectly clean, and the volume of water employed for this purpose is usually large. These waste waters are distinctly polluting liquids.

Volume of waste liquids.

21. A distillery which uses 1,000 bushels of barley per week—that is a distillery of medium size—would produce each week approximately:—

Steep water (quiescent steeping)	8,000 gallons.
Pot ale	13,000 ,,
Spent lees	4,000 ,,
Wash waters	20,000 ,,

22. Of these liquids, pot-ale may be regarded as being about 40 times as strong as ordinary sewage, or even more than that, and steep water (from quiescent steeping) as 3 to 10 times as strong. Spent lees are much weaker: we have not many data with regard to this waste liquor, but it probably requires less oxygen for its complete oxidation than a sewage of average strength.

Wash waters naturally vary greatly in strength, but taken as a whole they can be regarded as weak liquids in comparison with steep water and pot-ale.

III. EVIDENCE OF EXPERTS.

23. At an early stage of our investigations (in January and February, 1906), we took the evidence of the following witnesses:—

Mr. John Hunter, F.I.C., F.C.S.

Mr. James Burgess Readman, D.Sc., F.R.S.E.

Mr. Robert Rattray Tatlock, F.R.S.E., F.I.C., F.C.S.

Mr. John H. Fullarton, M.A., D.Sc.

Mr. James Hendrick, B.Sc., F.I.C.

Mr. Stevenson Macadam, F.I.C., F.C.S.

This evidence was published in Appendix I. to our fifth report.

The general opinion of these experts was that land treatment, if properly conducted, was a satisfactory method of purification, but that treatment by means of bacterial filters was not satisfactory.

Hendrick, 26914, 26916, 26918, 26925.

Mr. Hendrick, however, who had himself made some valuable experiments on the subject some years previously, was of opinion that satisfactory purification could be obtained by percolating filters, if the liquid to be treated were made up of proportionate quantities of the various waste liquids from a distillery, and if it were first subjected to chemical purification.

Macadam, 26955. Readman, 26612. Tatlock, 26637, 26656.

As regards the disposal of pot-ale by evaporation and torrefaction, Mr. Stevenson Macadam went so far as to say that he thought it was the only method available, while Dr. Readman and Mr. Tatlock also spoke very favourably of this process, though the latter witness said there had been complaints of smell from it, the grounds for which he thought had now been removed.

Fullarton, 26755–7.

Dr. Fullarton gave a favourable account of a method by which pot-ale is sprayed into the chimney and so destroyed.

IV. LAND TREATMENT.

24. Several witnesses expressed the view that, under suitable conditions, pot-ale can be efficiently purified by applying it to land, and that the land is thereby improved.

Our own observations at Glenlivet, Dailuaine, Mortlach and elsewhere confirm this view. In the case of grass lands in particular, pot-ale, if properly applied, is of considerable benefit. In order that the land treatment may be successful, it is essential that the pot-ale should be carefully distributed, and it is generally desirable that the solids should first be settled out. At Glenlivet it was found that the solids, which chiefly consisted of burst yeast cells, killed the young grass shoots.

In most, if not all instances, we think it will be found advantageous to lime the land from time to time.

25. Some particulars as to the cost of disposing of pot-ale on land at certain places are contained in Mr. Littlefield's report.* The cost at any particular place will, of course, depend largely on the price and character of the land and the expenditure required to distribute the pot-ale upon it, and no figures of cost can be given which would be of general application.

26. Although we have had no opportunity of examining the treatment of the other waste liquids on land, we have no doubt that, where the conditions are suitable, they also could be satisfactorily dealt with by land treatment.

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* *See* Appendix II.

V. DESTRUCTION BY HEAT.

27. We have had under observation three or four different plants for destroying pot-ale by heat.

Convalmore.

28. At Convalmore, the plant which is known as the "Lennox" evaporator consists of a series of chambers placed at the foot of the chimney, into which the pot-ale is sprayed in fine jets. The chambers are heated partly by the waste heat from the boiler furnace and partly by an auxiliary furnace.

A somewhat sticky substance is left behind in the chambers, and this, we were informed, was sold at 22s. 6d. per ton for use as manure.

Ben Rinnes.

29. At Ben Rinnes, the two chimney stacks are each provided with a stout coil of copper pipe, into which pot-ale is forced at a pressure of from 50 to 60 lbs. to the square inch. The pot-ale emerges from the coil at the bottom of the chimney and gets more or less dried in its passage upwards. A considerable amount of the pot-ale adheres to the inside of the chimney and is destroyed when the chimney takes fire, which happens about once a week.

The process has been working about six years, and the Manager reports that no apparent damage has been done to the chimney.

Knockando and Longmorn.

30. At these distilleries the process of the "Liquid Destructor Co., Ltd.," is in use.

A number of trays, which are heated partly by the waste heat from the boiler furnaces and partly by an auxiliary furnace, are placed in flues at the bottom of the chimney, and over these trays pot-ale is allowed to flow continuously. The speed of flow is so arranged as to allow the pot-ale to become dried and charred. The product is of some value as a manure.

At Longmorn the waste heat alone is utilised to heat the trays.

OBSERVATIONS ON DESTRUCTOR PROCESSES.

31. These destructor processes are only available for dealing with the pot-ale, and where they are used some other means are required for purifying the other waste liquids, the volume of which is more than twice as great as the volume of pot-ale. So far as the pot-ale is concerned, pollution of the stream is entirely obviated, but from all the processes which we have had under observation an acrid and penetrating odour of an objectionable character is at times given off, which can be detected two or three miles away.

In no case have we found that the waste heat of a distillery is sufficient to destroy more than about one third of the pot-ale produced.

VI. EVAPORATION FOLLOWED BY TORREFACTION.

32. The chief example of this process is to be found at the town of Rothes, where a plant has been erected by the proprietors of four distilleries.

Macadam, 26955. When Mr. Stevenson Macadam, the chemical adviser of the riparian proprietors, gave evidence before us in 1906, he spoke of this process as "the only method," and in a letter which Messrs. John C. Brodie & Sons, the solicitors to the proprietors, addressed to one of the distillers, it is stated "our past experience of bacteria bed processes or indeed of any process of treatment is not such that we can place any reliance upon any method of disposal of the ale short of complete destruction by evaporation or otherwise."

More recently, in his report* of July last on the Coleburn experiments, Mr. Stevenson Macadam has taken occasion to advocate in strong terms the advantages of the process of evaporation. For these reasons the process has merited special attention.

33. The process at Rothes is carried out as follows—

From the receiving tanks the pot-ale is pumped into the first of a series of five large evaporating vacuum chambers, so arranged that a graduated reduced pressure enables the waste heat from one unit to cause the pot ale in the next unit to boil. Boiling is brought about by the passage of steam through a large number of tubes placed vertically in the chambers, the boiling temperature in the first chamber being 104° C. At suitable intervals, in practice about every half hour, the contents of one chamber are sucked into the next, and so on through the whole series. The liquor in the second unit boils at about 92° C., in the third at 86° C., in the fourth at 78° C., and in the fifth and last, where the pressure is reduced to about 3″ of mercury, at 55° C. By a trapping arrangement the syrup in the last unit can be run off without interfering with the vacuum in the series. The plant was designed and erected by Messrs. Mirrlees, Watson & Co., Glasgow, and the fact that in practice each pound of fuel reduces from 22–23 lbs. of pot ale to 7 per cent. of its original volume, shows that it is very economical.

All portions of the apparatus which come in contact with the pot ale are made of gun-metal.

In the second stage of the disposal the thick pot ale syrup is run into shallow iron pans, which are caused to traverse a long flue, through which the products of combustion from the boiler furnace and an auxiliary furnace are passing. These flues are about 30 yards in length and the temperature at the entry is about 260° C., and at the exit 120–135° C. The bottom of each pan is covered with a layer of the syrup about an inch deep, and the rate of passage through the flues is so arranged that the syrup is reduced to a charred mass by the time it reaches the exit end.

The material remaining in the pans is then chipped or scraped out and allowed to cool. Sufficient draught through the flue is produced by a tall chimney, and all the products of combustion pass into the air. The charred residue is ground to a fine powder which was meeting with a ready sale as a manure.

Cost of Process.

34. The Manager has kindly supplied us with the following figures as to the cost of this process.

The total capital invested, including working capital, is £14,000, of which, roughly speaking, buildings account for £6,000 and plant for £7,000.

During the season 1906–7, a period of 47 weeks, about 2,900,000 gallons of pot ale together with 250,000 gallons of leakage water, were evaporated and incinerated, yielding 300 tons of saleable manure. The average working hours per week were 51 under steam and 57 in the drying ovens.

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* See Appendix VI.

The 2,900,000 gallons of pot-ale is approximately equivalent to 210,000 bushels of malt, or an average of about 4,400 bushels per week for 47 weeks.

The average price of the manure sold was £4 15s. per ton, the actual sales producing £1,435 during the period.

The costs may be apportioned thus :—

	£.
Wages and salaries - - - - - - -	564
Fuel and oil - - - - - - - -	1,000
Repairs - - - - - - - - -	26
All other expenses - - - - - - -	500
	2,090
Less cash for manure - - - - - - -	1,435
Leaving a net loss of - - - - - - -	£655 per annum.

The average price of coal was 17s. 8d. per ton.

We are informed that the plant was surveyed in 1907, after 16 months working and that it then showed little evidence of depreciation.

The rate of depreciation of the plant would, of course, be an important element in determining the actual cost of this process, but we do not think that the experience of its working has been sufficient to justify the making of any really reliable statement at the present time as to what the rate of depreciation would be in practice.

A similar evaporating plant, but on a smaller scale, was erected at Glen Dullan distillery and was found to require practical renovation at the end of five years' working.

On the basis of the data supplied, the total annual cost of the Rothes plant, allowing ten per cent. depreciation on the evaporators, and two per cent. on the buildings, and interest at four per cent. on capital, would be about £2,000.

It will be noticed that it requires four tons of fuel to produce one ton of saleable manure, so that any serious rise in the cost of fuel must considerably increase the cost of the manure and consequently the loss on marketing it.

It is possible that the cost of working this process may, in time, be reduced. At present it is far from being self-supporting.

OBSERVATIONS ON THE PROCESS OF EVAPORATION AND TORREFACTION AT ROTHES.

35. The distillate from the evaporating chambers is cooled by admixture with about 30 volumes of water and then run into a small burn, which discharges into the Spey. Mr. Tatlock, when giving evidence before us, referred to the distillate as "distilled water," but examination of the burn, from time to time, has generally shown the presence of more or less grey growths at or below the entry of the discharge pipe from the works. In the last of the evaporating units, the syrup is boiling under a very reduced pressure, and some of it is, no doubt, carried over by splashing or in a finely divided form. At this stage of the operation the pot ale is in its most concentrated state, and the admixture of a little would cause the whole distillate to become a distinctly polluting liquid. Attempts are being made to minimise this splashing; but any serious reduction in the vacuum would naturally diminish the economy of the plant.

An analysis was made of a sample of the distillate in June, 1906, the sample having been taken continuously over a period of two hours. The following figures were obtained:—

	Parts per 100,000.
Ammoniacal Nitrogen - - - -	0·03
Albuminoid Nitrogen - - - -	0·03
"Oxygen absorbed" from $\frac{N}{8}$ permanganate at 27°C. (80°F.) *at once* -	0·54
"Oxygen absorbed" from $\frac{N}{8}$ permanganate at 27°C. (80°F.) *in 4 hours* -	10·88
Dissolved oxygen taken up from water in 7 days - - - - - -	at least 7·4
Total solids - - - - - -	10·20 {5·88 volatile. 4·32 non-volatile.

Another analysis was made of a sample of the distillate taken in March, 1907, at which time there were grey fungoid growths in the burn, and the following results were obtained:—

	Parts per 100,000.
Ammoniacal Nitrogen - - -	·036
Albuminoid Nitrogen - - -	·048
Oxygen absorbed from $\frac{N}{8}$ Permanganate at 27°C. in four hours -	47·20

There can be no doubt that the distillate from this process, as now carried on, is frequently a polluting liquid which takes up oxygen fairly rapidly from water and causes in the burn growth of fungus.

If the effluent were to flow into a stream the volume of which was small compared to the volume of the effluent, a nuisance would probably be caused.

36. This process only deals with pot ale and, where used, some other means are required for purifying the other waste liquids, the volume of which is more than twice as great as the original volume of pot ale.

37. An acrid and penetrating odour of an objectionable character, which can be detected two or three miles away from the works, is at times given off from the Rothes plant and the same thing has been noticed in the case of the similar plant at Tamdhu distillery.

VII. PURIFICATION BY MEANS OF CONTACT BEDS.

38. At a number of distilleries contact beds have been provided for the treatment of the waste liquids. The beds have usually been arranged in a series of six or seven, so that the liquid passes successively through each bed of the series.

At Aberlour, the pot-ale is treated chemically by a process due to Mr. Hunter, before it is passed to the contact beds.

In Mr. Littlefield's report details as to the working of these contact beds at some places are given.

We find that this type of filter is not well adapted for the treatment of very strong liquids, such as crude pot ale.

39. We have carried out a few experiments at the Mortlach Distillery, with a view to ascertaining whether, by first diluting the waste liquids with water, adding lime, and then settling, a more satisfactory effluent could be produced. Progressive rates of filtration were tried upon the series of six contact beds. Though a high percentage purification was always obtained, the final effluent was putrescible on incubation.

At the highest rate of filtration, in June, 1908, when the beds were well matured and the weather mild, the volume of limed liquor treated (pot ale, limed and diluted with water to 10 times its original volume) was 20 gallons per cube yard per day, equal to 2 gallons of pot ale. The purification obtained, based on the "oxygen absorbed" from permanganate in 4 hours, was then 93·5 per cent., the liquor under treatment having an average oxygen absorbed of 75·0 and the final effluent one of 4·9. The figures for dissolved oxygen absorption in 5 days, given by two samples of final effluent drawn on June 4th and 15th, were 5·5 and 7·5, respectively.

The conclusion to be drawn, therefore, is that six contacts are not sufficient to produce a high class effluent.

We have also had an opportunity of observing the treatment of a strong steep water, limed and settled, on the six contact beds at Mortlach—again at the rate of 20 gallons of limed liquor per cube yard per day. The limed liquor in this case varied greatly in strength, its average figure for "oxygen absorbed" in 4 hours (as shown by five samples drawn over a period of six weeks), being 51·0 (25·7 to 84·5). The corresponding figure for the final effluent, which was putrescent upon incubation, was 10·3 (4·2 to 19·5). The extent of purification effected by the contact beds, based on the "oxygen absorbed" in 4 hours, was 80 per cent. We ought to add that this effluent received its final purification upon land.

VIII. PURIFICATION BY MEANS OF PERCOLATING FILTERS AT THE COLEBURN DISTILLERY.

40. Our experience in connection with the treatment of sewage, together with our observations of the working of the bacteria beds which had been provided at distilleries, led us to anticipate that the purification of distillery liquids might be better effected by percolating filters than by contact beds, and, at our suggestion, a percolating plant was erected at the Coleburn Distillery, at the cost of certain distillers.

Some laboratory experiments which had been made by our chemist, Dr. McGowan,[*] on the purification of pot ale, showed that it would be desirable to dilute the pot ale, and then to precipitate it with lime, before attempting to oxidize it on a filter. Accordingly the plant at Coleburn was designed so as to allow of this process being tried on a practical scale.

Somewhat similar experiments to those of Dr. McGowan had previously been made by Professor Hendrick, an account of which appears in a paper entitled "The composition and disposal of burnt ale and of other waste liquids from whisky distilleries" (*Journal Society Chemical Ind.* May, 1901).

41. A detailed account of our work at Coleburn is given in Mr. Littlefield's Report[†] and in Dr. McGowan's memorandum[‡] on the working of the Coleburn filters.

The general method of working the process adopted at Coleburn has been to mix all the waste liquids in the proportions in which they are produced, to dilute this mixture with water and then to precipitate with milk of lime, the ultimate volume of the mixed liquid being ten [§] times the volume of the original pot ale.

The tank liquor so produced has been run through a percolating filter 24 feet in diameter, and 12 feet deep, filled with pieces of coke, of good quality, varying from 1 in. to 3 in. in diameter, and fed by an intermittently revolving sprinkler. After the first year the filter was provided with a cover to protect it from the weather. The filtrate has been passed through shallow filters composed of a layer of sand 1 in. thick, standing on a layer of gravel 3 in. thick. The object of the latter filters was to remove the suspended solids from the effluent.

42. Analyses of the liquids have been frequently made and a number of analytical figures are given in Mr. Littlefield's Report[†] and in the Tables of Analyses.[||]

The average composition of the liquor going on to the large filter has been :—

—	During 1906–7.	During 1907–8.[¶]
	Parts per 100,000.	
Ammoniacal Nitrogen	0·69	0·42
Albuminoid Nitrogen	5·61	2·88
Total Nitrogen	—	6·63
Oxygen absorbed from $\frac{N}{8}$ permanganate, at 27° C., at once	—	4·57
Oxygen absorbed from $\frac{N}{8}$ permanganate, at 27° C., in 4 hours	92·0	71·10
Chlorine	—	3·93
Solids in suspension (gravimetrically)	—	6·13
Solids in suspension as determined by centrifuge	—	16·00
Dissolved Oxygen required for complete oxidation	—	280–300 (calculated)

During 1906–7 work was carried on six days a week. In 1907–8 the filter was worked continuously.

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[*] *See* Appendix I.

[†] *See* Appendix II.

[‡] *See* Appendix III.

[§] We are at present treating on the Coleburn plant a liquid of only half this dilution, and, so far, with success.

[||] *See* Appendix V.

[¶] During 1907–8 the Coleburn distillery was not working, and the liquid treated was pot-ale carted from other distilleries.

The average analysis of the final effluent, which was of very constant composition, has been:—

—	1906–7.	—	1907–8.
	Parts per 100,000.		Parts per 100,000.
Ammoniacal nitrogen - -	0·12	Ammoniacal nitrogen - - -	0·03
Albuminoid nitrogen - -	0·28	Albuminoid nitrogen - - -	0·14
Nitric nitrogen - - - - -	1·12	Total organic nitrogen -	0·36
Oxygen absorbed from $\frac{N}{8}$ permanganate in 4 hours at 27° C. - - -	2·61	Nitrous nitrogen - - - -	0·01
Dissolved oxygen taken up from water in 5 days at 27° C. -	0·59	Nitric nitrogen - - - -	0·66
Alkalinity (as CaO) - - -	15·80	Total nitrogen - - - -	1·13
		Oxygen absorbed from $\frac{N}{8}$ permanganate at once - - -	0·43
		Oxygen absorbed from $\frac{N}{8}$ permanganate in 4 hours - - -	1·75
		Dissolved oxygen taken up from water in 48 hours at 27° C. -	0·30
		Dissolved oxygen taken up from water in 5 days at 27° C. - -	0·74
		Oxygen in solution - - -	0·80
		Oxygen remaining after incubation for 5 days - - - -	0·43
		Alkalinity (as CaO) - - -	12·50
		Solids in suspension - - -	less than 1·0

43. From June to September, 1906, the distillery was not working, and the liquid treated consisted of a mixture of nine parts of water to one part of pot-ale limed and settled. The pot-ale was stored for the purpose of working the filter.

At the commencement of the distilling season, 1906–7, steep water only was available, and from the 25th September to 25th October, 1906, the filter was treating undiluted limed steep water at the rate of about 1,100 gallons a day, which was the whole output of the distillery. The four hours "oxygen absorbed" figure of the limed steep water was 57·7 parts per 100,000, and the corresponding figure for the effluent, after removal of solids, was 1·6 parts per 100,000.

44. From November, 1906, to the 20th June, 1907, the plant treated 4,000 gallons of liquid per day, made up of 400 gallons of pot-ale, 1,000 gallons of other waste liquids, and 2,600 gallons of water.

This was equivalent to two gallons of pot-ale, together with 4·5 gallons of other waste liquids, per cube yard of filter per day.

From the middle of November, 1907, to the end of June, 1908, the plant was treating 330 gallons of pot ale, diluted to 4,000 gallons per day, seven days a week.

The average analyses of the liquid going on to the filter and of the final effluent have already been given.

Throughout these periods the effluent was non-putrescible, and was capable of taking up oxygen only very slowly from water.

Channel Experiments.

45. The interpretation of figures of chemical analysis of effluents has not, as a rule, been sufficiently considered in connection with the actual effects of effluents on streams.

Our own work, and the work done by others, has satisfied us that figures of analysis, if considered merely with reference to the amount of organic matter contained in an effluent, and without reference to the condition of that organic matter, may lead to wrong inferences.

Speaking generally, what is required of an effluent, in order that it may be regarded as satisfactory, is that it shall not injuriously affect the stream into which it is discharged. The chief injuries to be avoided are the deposition of solids in the stream; the taking up of oxygen from the stream more rapidly than the stream takes up oxygen from the atmosphere; the promotion of the growth of noxious fungus in the stream; injuries to fish life; and the modification of the quality of the water so that it is not suitable for any purpose for which it may be required.

Whether an effluent will or will not adversely affect a stream in the above ways depends rather on the condition of the organic matter remaining in it than on the absolute amount of that organic matter.

46. To test the actual effect of the effluent from our Coleburn plant on a stream, we constructed a number of long channels, or artificial streams, along which the effluent was allowed to flow.

In one of these channels the undiluted effluent flowed, in another the effluent with an equal volume of water, and in a third water alone.

Neither in the artificial stream containing effluent alone, nor in that containing effluent and water was any injurious effect produced. Also it was proved by experiment that this effluent was harmless to trout.

In this way, as well as by numerous analyses, it was demonstrated that the effluent was one which would not injure a stream in any of the ways already mentioned as necessary of avoidance.

The effluent itself could be re-used for diluting the pot-ale and other waste liquids, before the liming, so that the amount of effluent which would be discharged from this process need not be other than relatively small.

Bacteriological Character of Effluent.

47. The bacteriological quality of the effluents from distilleries is of secondary importance from the point of view of our Inquiry.

Nevertheless, a considerable number of samples have been examined bacteriologically.

The processes resulting in the production of pot ale must necessarily destroy all bacteria contained in it; the microbes found in stale pot ale are derived from extraneous sources of contamination and have, therefore, no necessary relation to the production of whisky.

The bacteria in "steep water" however, are not foreign to the process of manufacture, and as a matter of fact "steep water" is rich in microbial life. It contains many coli-like microbes, but the great majority of these germs differ from those associated with undesirable sewage pollution. The discharge of bacteria of this sort into non-drinking water streams is not to be regarded as objectionable. In the case of drinking water streams, far more objectionable pollutions arise from the manuring of land adjoining such rivers which inevitably results in excremental bacteria being washed into ditches and water-courses, whenever a flood occurs.

Our experiments at Coleburn showed that the filtration treatment adopted reduced to a remarkable extent the number of bacteria in the liquid undergoing treatment.

IX. EXPERIMENTS AT COLEBURN FOR THE PURPOSE OF ASCERTAINING WHETHER THE EFFLUENT WOULD HAVE ANY INJURIOUS EFFECT ON SALMON.

48. In the Spey district, the salmon fisheries are of considerable importance, and although it appeared to be highly improbable that the effluent from the Coleburn plant would injuriously affect salmon fisheries there in any way, we considered it was important to test this by actual experiment.

We conferred with Mr. W. E. Archer, Assistant Secretary of the Board of Agriculture and Fisheries, and with Mr. W. L. Calderwood, Inspector of Salmon Fisheries for Scotland, as to the way in which this question could be experimentally determined.

At their suggestion a hatchery for salmon was erected at Coleburn, and experiments were continued from December, 1907, to June, 1908.

The experiments were carried out under the supervision of Mr. Calderwood and our resident chemist Mr. Littlefield, and a full account of them is given in a report by these gentlemen which is published as Appendix IV. to this report.

The experiments were visited by some of us from time to time, and also by Mr. Archer.

49. Four pairs of tanks were provided and labelled respectively:—

(1) A and A^1.
(2) B and B^1.
(3) C and C^1.
(4) D and D^1.

Through the first pair undiluted effluent was allowed to flow; through the second pair a mixture consisting of 40 per cent. of effluent and 60 per cent. of water; through the third a mixture consisting of 4 per cent. of effluent and 96 per cent. of water; and through the fourth pair water alone, as a control.

50. By the courtesy of His Grace the Duke of Richmond and Gordon we obtained 50 salmon fry aged 20 months, 50 parr aged 8 months, and a suitable supply of salmon ova.

Into each of the tanks A, B, C and D, ten fish of each age were placed, and into each of the tanks A^1, B^1, C^1 and D^1 about 3,000 eggs. This was done on the 12th of December, 1907. On the next day the few eggs which had been damaged in transit were removed from the tanks.

The development of the fish in the four tanks was well marked, but undoubtedly the fish in tanks A and B grew faster, as is proved by the records.

The hatching out was also equally successful in all the tanks, and there can be no doubt that the effluent had no deleterious effect on the ova.

In regard to this experiment, Mr. Calderwood states that "the test was more severe than could possibly occur in nature in the neighbourhood of any distillery at which this method of treatment might be adopted."

We wish to express our great indebtedness to Mr. Calderwood for his invaluable services in connection with these experiments.

X. PURIFICATION OF REFUSE FROM GRAIN DISTILLERIES.

51. We have made no experiments in regard to the purification of the refuse from "grain" distilleries. As a rule these are situated in towns and the refuse is allowed to enter the sewers.

Through the courtesy of Messrs. J. Watney & Co., we have examined the processes which are followed in this type of distillery, and have obtained samples of the various waste liquors produced.

Our analyses of these samples show that the waste liquids are similar in character to those from "all malt" distilleries, but not so strong, and we have no doubt that they could be purified by similar means.

XI. SOME OBSERVATIONS ON THE ATTITUDE OF THE RIPARIAN PROPRIETORS AND ON THE QUESTION OF STANDARDS.

52. Although the riparian proprietors decided not to attend the preliminary conference which was held at Craigellachie for the purpose of discussing with them and the distillers the lines on which our investigations could most usefully proceed, we have kept them informed of our work, and given them every opportunity of visiting the experimental stations.

53. We have received from their solicitors, Messrs. John C. Brodie & Sons, a report made to the riparian proprietors by Mr. Stevenson Macadam on the Coleburn experiments which we have described. This report, which is published as Appendix VI., seems to us to illustrate in a striking manner the erroneous conclusions which may be arrived at in regard to an effluent if certain analytical figures are alone considered.

In his report Mr. Macadam states:—

> "When I was at the works last year the pure effluent, and the effluent diluted with water, were being passed along different artificial channels containing gravel, and this had been so for some time. I examined the channels and did not observe any indication of unhealthy growths. I also examined the small ditch, into which the discharges passed, with a similar result. The ditch contained abundance of fresh green water plants, and they appeared healthy in every respect. This ditch ultimately joins the Cole Burn, and no effect was noticeable on the stream.
>
> "In December of last year a small experimental hatchery was erected in connection with the purification works, and I understand that 3,000 Salmon ova, placed in tanks fed by the effluent, all hatched out. When I was there in June I saw the young fish and some small parr in different sets of tanks. One set of tanks were entirely fed with pure effluent, and others with varying mixtures of effluent and water. The fish were all perfectly healthy and appeared to be thriving excellently. I also examined the artificial discharge track, from the hatchery to the ditch, and could not notice any sign of pollution. Owing to the very warm weather which had existed for some time no natural water was running in the ditch, and the small flow from the hatchery was lost in the ground before it reached the Cole Burn, so that observations could not be made there."
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> * * * * * *
>
> "The results of my observations on the discharge tracks, ditch, and Cole Burn, and the results of the fish experiments, certainly show that, under circumstances as they exist at Coleburn, noxious growths are not produced, and fish thrive. I am of opinion that the presence of the discharge in a stream would not interfere with angling."

54. Nevertheless, notwithstanding these observations of his as to the actual effect of the effluent on streams and on salmon, Mr. Macadam states that the analytical results show that it "is still a polluting liquid." Although, technically, this statement may be correct, it appears to us that the term "polluting" should only be applied to a liquid which will produce actual injury to a stream into which it may be discharged.

Much of the Report of Mr. Macadam's which is in question is taken up by advocacy of the merits of processes of evaporation with a view to the production of a marketable manure, and he concludes by stating that he is of opinion "that the quality of effluent, if effluent there is to be, which the riparian proprietors require, can only be obtained by a process of evaporation."

As an abstract proposition we agree with Mr. Macadam in favouring processes by which the valuable constituents of waste products may be utilised.

The manufacturer, however, must regard the question from a financial point of view and at present it costs considerably more to produce manure from the waste liquids of a distillery than the manure will sell for.

55. We do not agree with Mr. Macadam's conclusion that the effluent which the riparian owners require can only be obtained by a process of evaporation. The evaporating processes, as now carried on, deal solely with the pot ale. This forms only about one-third of the waste liquids of a distillery, and according to present knowledge it would be impracticable to evaporate the whole of the waste liquids, while as regards the part which is dealt with by evaporation, the distillate which is produced is a liquid which takes up oxygen fairly rapidly from water, which promotes the growth of fungus in a stream, and which might, if not very largely diluted, be injurious to fish.

56. As regards the effluent which the riparian proprietors require, any claim that the effluent shall in composition be identical with the river water, without reference to the question of damage, is not, in our opinion, one which should be entertained.

There are undoubtedly a large number of instances in which it would be physically impossible for any such demand to be satisfied; and, if it were to be insisted on, it would involve the stoppage of many of the distilleries of the country.

57. The extent to which distillery effluents need be purified, in order that no damage should be caused to the stream into which they are discharged, would vary with the particular circumstances.

In the case of small fishing rivers such as the Dullan and Fiddich, where a high standard of effluent is necessary, we consider that an effluent would probably prove satisfactory if it complied with the following conditions:—

(1) That it should not contain more than three parts per 100,000 of suspended matter;

(2) That it should be non-putrescible on incubation; and

(3) That, after being filtered through filter paper, it should not absorb more than 1·5 parts *by weight* per 100,000 of dissolved or atmospheric oxygen in five days.

This is quite a practicable standard of purification. The effluent from the plant at Coleburn was generally much better.

In many other cases a lower standard would, in our opinion, suffice.

XII. CONCLUSIONS.

1. It is practicable to treat the waste liquids from distilleries either on land or on filters so as to produce a satisfactory effluent.

2. For treatment of these liquids, percolating filters are more efficient than contact beds, and, according to present knowledge, it appears to be desirable first to dilute the waste liquids and then to treat them with lime before filtering them.

3. It is practicable to destroy *pot ale* by heat. For this purpose the waste heat of the works may be utilised, but this alone is only sufficient to destroy about one-third of the pot ale produced.

4. It is practicable to evaporate *pot ale* and then to incinerate the syrup so as to produce a manure which at present sells fairly well at about £5 a ton.

The revenue from the sale of such manure falls far short of the expenditure required to produce it.

There is some risk of atmospheric nuisance with these destructor and evaporation processes, as at present carried on, and the distillate from the evaporation process is a liquid which would be liable to cause a nuisance if discharged into a small stream.

5. The cost of the various methods of dealing with the waste liquids from distilleries would depend largely on local circumstances. Where suitable land was available at an agricultural price, land treatment would be the most economical process to adopt, but great care would be required to secure that the land is not overdosed and that the waste liquids are properly distributed over it.

Of the artificial processes, the plan which has been carried out at Coleburn would, in our opinion, be considerably cheaper than any of the destructor or evaporation processes, especially in view of the fact that these processes only deal with *pot ale*. So that where they are adopted further means must be provided for purifying the other waste liquids.

In making this statement we are assuming that skilled supervision would be required in all cases, but especially in the case of the process which has been carried out at Coleburn.

6. The Central Authority,* which we have recommended to be constituted, should be the final tribunal to determine all questions relating to standards.

7. In the case of distilleries situated in towns which are sewered, we think, as a general rule, the liquid refuse should be allowed to enter the sewers. Its admission to the sewers should be subject to regulations and safeguards as recommended in our Third Report† dealing with the relations between local authorities and manufacturers in regard to the disposal of manufacturing effluents.

IDDESLEIGH (Chairman).
T. WALTER HARDING.
WILLIAM RAMSAY.
W. H. POWER.
T. J. STAFFORD.
R. A. TATTON.

F. J. WILLIS (Secretary).
9th February, 1909.

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* Third Report, 1903. (Cd.1486). Paragraphs 40–50. Fifth Report, 1908. (Cd. 4278). Paragraphs 316–319.
† Third Report, 1903. (Cd. 1486). Paragraph 22.

APPENDIX I.

SOME PRELIMINARY EXPERIMENTS ON THE PURIFICATION OF POT-ALE.*

During the recent tour of the Commission in the Highlands, two distilleries among others were visited, viz., Cardow and Mortlach, where it was attempted to purify the pot-ale, admixed with steep liquors, etc., by an elaborate system of eight and seven contact beds respectively; the first bed was constructed of very coarse material and the last one of dust. The figures of the chemical analysis of a chance sample of effluent from each of the two places were as follows :—

Analysis made	Parts per 100,000 by weight.	
	Cardow Distillery, May 27th, 1903.	Mortlach Distillery, May 29th, 1903.
Ammoniacal nitrogen - - - - - - - - -	4·69	22·40
Albuminoid nitrogen† - - - - - - - - -	1·08	2·86
Total organic nitrogen - - - - - - - - -	2·35	5·69
Nitrous nitrogen - - - - - - - - - -	0·00	—
Nitric nitrogen - - - - - - - - - -	0·00	—
Total nitrogen by Kjeldahl method - - - - - - - -	7·04	28·09
Oxygen absorbed from $\frac{N}{8}$ permanganate at 27°C. (80°F.) *at once* - -	2·90	8·66
„ „ „ „ *after 4 hours* -	11·97	23·54
Chlorine - - - - - - - - - - - -	8·04	22·76
Total solids (gravimetrically) - - - - - - - -	170·5 {58·2 Vol., 112·3 Non-vol.	338·9 {71·6 Vol., 267·3 Non-vol.
Solids in suspension - - - - - - - - -	29·05 {15·8 Vol., 13·25 Non-vol.	14·45 {12·1 Vol., 2·35 Non-vol.
Solids in solution - - - - - - - - -	141·45 {42·4 Vol., 99·05 Non-vol.	324·45 {59·5 Vol., 264·95 Non-vol.
Solids by centrifuge (vols.) - - - - - - - - -	33	25

Both of the effluents were bad, the purification being far from efficient.

It was evident to the Commission at the time of their visits that the principle of the above method of purification was faulty, because (1) an extremely acid liquor was being dealt with, which only became neutral after emerging from the fifth or sixth contact bed, and (2) the liquor was so strong organically as to require a very large quantity of oxygen for its complete oxidation.

Bearing the above points in mind, the following preliminary experiments have been carried out with a sample of pot-ale sent from Mortlach by Dr. Cowie. A wide glass tube, 3 feet 10 inches long and 2½ inches internal diameter, was closed at its lower end by a rubber stopper, through which five small and short glass tubes were passed, to assist in the aeration.‡ The tube was filled with coke collected by Mr. Frye from the uppermost tray of the Scott-Moncrieff installation at Caterham Barracks, the pieces ranging from ¼ inch to ½ inch in diameter (roughly). This coke was of course thoroughly matured, and ready to induce nitrification in any suitable liquid that might be filtered through it. The actual depth of coke in the tube was about 3 feet 7 inches—say, 3½ feet. The liquid to be filtered was contained in an inverted Winchester quart bottle, with air-inlet tube, the rate at which the liquid escaped being regulated by a screw clip, acting on a rubber joint.

When the jar of pot-ale was opened on July 1st, it was found that about 900 c.c. of clear lime water were required to neutralize 500 c.c. of the pot-ale; and, standing since then in a half-empty jar, it has gradually become more acid. Roughly speaking, two volumes of clear lime water are wanted to neutralize one volume of pot-ale; or, 1 gallon (of this sample) of pot-ale requires something like 130 to 140 grains of quicklime to neutralize the free acid present.

The effect of neutralizing one volume of pot-ale with two volumes of lime water is to throw down a bulky flocculent precipitate, which readily settles,§ leaving an almost clear, amber-coloured liquid. How strong this liquid is, organically, is shown by the fact that, even when diluted with nineteen volumes of tap water (*i.e.*, diluted to sixty times the volume of the original pot-ale), it becomes putrid upon incubation; possibly the limit of dilution may be considerably beyond this. The liquid, if allowed to stand, ferments very rapidly, becoming turbid with mouldy growths, and acquiring an acid reaction *and a most offensive odour*. In practice, therefore, the sludge—containing of necessity some of the above liquid admixed with it—would have to be treated immediately, either by pressing or by some other suitable method, if a nuisance was to be avoided. It would however, be valuable as a manure. Examined under the microscope, it was seen to consist mainly of yeast cells; and a small portion of it, after drying, gave the following (round) figures:—

---

* These were carried out in 1903.

† Distilled water from an ordinary continuous-feed copper still was used for the analyses given in this appendix.

‡ *Note.*—As a matter of fact, the lower ends of those small tubes became sealed by liquid; a piece of string has therefore been inserted in each tube, which keeps it open (October 10th).

§ *Note.*—October 9th, 1903. The precipitate thrown down on October 7th from 250 c.c. pot-ale, 850 c.c. lime water and 750 c.c. water was filtered, washed, and dried at 100° C. It weighed 2·09 grm. (0·84 per cent. by weight of the pot-ale taken). This weight is less than one-third of that of the lime added. If we assume the inorganic portion of this precipitate to be tribasic phosphate of lime (see below), then something like three-fourths or five-sixths of the lime added for neutralization passes away in the effluent.

Volatile matter - - -	75 per cent.
Non-Volatile matter - - -	25 „ „

The volatile matter must of course be nitrogenous,* and the non-volatile matter, tested qualitatively, appears to consist almost entirely of tribasic phosphate of lime, of course in a very finely divided condition and therefore readily assimilable by plants.

During July, and again for the past month, considerable quantities of liquid, prepared as above, have been passed at a slow rate through the coke filter, and nearly all of the filtrates have been tested, so far as time permitted. (N.B.—The estimation of nitrate was in nearly every instance done, for the sake of quickness, by the pyrogallic acid method.) So far as they go, the figures of analysis may be taken as substantially correct.

Instead of giving detailed results at the present stage, a short summary may suffice:—

(1) Between July 2nd and 17th, 1903, limed effluent of the above strength, *i.e.*, roughly of one-third the organic strength of the pot-ale, minus the sludge, was filtered at rates varying from 7 to 47 gallons of limed liquor per square yard per twenty-four hours, the *average* rate for the whole fifteen days being 14 gallons per square yard. In every case the filtrate, which was yellow to brown in colour and which contained some suspended matter, had a clean smell, and contained nitric plus nitrous nitrogen varying between 3·9 and 8 parts per 100,000, excepting in three instances where the larger volumes of 33, 35, and 47 gallons had been passed. These latter filtrates were clearly not sufficiently purified.

(2) July 21st to 24th. The insufficiently purified effluent of July 17th was refiltered at a rate of 13 to 16 gallons, when the oxidized nitrogen went up to 11 parts.

(3) July 25th to 31st. Tap water only was passed, at rates varying between 10 and 64 gallons per square yard per twenty-four hours. All the effluents were brown to lemon-coloured, contained a considerable quantity of washed-out solids, and had a clean smell, while the oxidized nitrogen varied between 3 and 13·5.

(4) August 1st to 6th. Fresh limed effluent of half the previous strength was passed at rates varying between 6 and 18 gallons; the oxidized nitrogen in three out of four filtrates was almost constant at 3·75 to 3·96 parts.

(5) August 6th to September 19th. The filter was occasionally moistened with sewage (a few hundred c.c. in all), which washed through a considerable quantity of brown solids. Filtrate not tested.

(6) September 19th to 21st. Fresh limed effluent of half strength, at rate of 45 gallons. The filtrate contained as much as 13 parts of nitric nitrogen (washed out of the filter), but the "oxygen absorbed" figure was 65, and the liquid—which had a smell like that of beer—was clearly not purified.

(7) September 24th to October 3rd. The above filtrate was re-filtered three times, at rates between 10 and 40 gallons, with the following results:—

——	Oxidized nitrogen.	"Oxygen absorbed" from permanganate in 4 hours at 27°C (80°F.)
1st filtration - - -	4·6	11·0
2nd „ - - -	4·6	3·9
3rd „ - - -	10·0	3·0

(8) October 3rd to 7th. Fresh limed effluent of half strength, at rate of 15 gallons:—

——	Oxidized nitrogen.	"Oxygen absorbed."
——	7·5	2·7

(9) October 7th to 10th	Oxidized nitrogen.	"Oxygen absorbed."
Fresh limed effluent of half strength, at 28 gallons:—	1·3	6·1

(10) October 10th to 13th. Fresh limed effluent of half strength, at 13 gallons:—

This limed effluent and the filtrate have been analysed more fully, with the following results:—

Parts per 100,000.	Limed† solution of Oct. 10th. Analysed Oct. 14th, 1903.	Effluent analysed Oct. 13th, 1903.
Ammoniacal nitrogen - -	2·50	0·04
Albuminoid nitrogen - -	5·51	0·26
Total organic nitrogen -	10·30	0·27
Nitrous nitrogen - - -	—	0·02
Nitric nitrogen - - -	—	1·34
Total nitrogen - - -	12·80	1·67
"Oxygen absorbed" at 27° C. (80° F.) *at once* - -	11·31	1·01
"Oxygen absorbed" *in four hours* - - -	83·37	3·74
Incubator test (by smell) -	—	Passed (Musty and unpleasant)

(11) October 14th to 15th. Same limed effluent at 28 and 8 gallons:—Oxidized nitrogen 1·1 and 3·1.

Provisional Conclusions.

The above experimental data are still very incomplete, extending as they do only over a short period of time, but they indicate the following:—

(1) When pot-ale is neutralized with lime water and the sludge is allowed to settle, the resulting liquid can be efficiently purified, at all events for some time, by passing it through a continuous filter, *which has in the first instance been matured by sewage.* The dilution should not be less than about six times the original volume of the pot-ale; probably it might with considerable advantage be greater. The analysis given shows the great organic strength of the limed liquor.

(2) The passage of liquid through the filter must of course be slow. With a filter three feet deep, containing material of ¼ inch to ½ inch diameter, probably not more than five to ten gallons of pot-ale (*i.e.*, the original pot-ale) per square yard could be purified satisfactorily in twenty-four hours. By a six-foot filter, preferably of somewhat larger material, probably ten to twenty gallons could be dealt with (*N.B.*—With good conditions of aeration, the figures might possibly be greater).

(3) When limed liquor is not being passed through the filter, river water might occasionally be used, with the object of washing out solids.

(4) The effluent would be excellent for passing over grass land.

(5) The precipitated sludge would probably prove the chief difficulty. It would have to be dealt with freshly, otherwise it would constitute a nuisance. From its composition, it would make a valuable manure.

(6) The above experiments indicate also that limed pot-ale liquor, sufficiently diluted, might also be treated on matured contact beds, at least for a time.

The experiments are being continued, nothing but limed pot-ale liquor being filtered. These will show whether the nitrifying organisms originally introduced by the sewage persist under the above conditions, a point on which Dr. Houston has already experimented in another direction; they should also give some indication of the possible length of "life" of such a filter. Many points of detail have been purposely left unmentioned here, *e.g.*, the condition of the filter as regards solids; the question of distribution (this would no doubt be troublesome); the possibility of nuisance arising from the smell of limed liquor which is allowed to stand. These and other matters can be more fitly discussed at a latter stage.

Ealing. GEORGE McGOWAN.

October 19th, 1903.

ADDENDUM.—The above laboratory filter was kept going with limed pot-ale liquor until August, 1904, and afterwards intermittently until July, 1906, and continued to work efficiently. It is now unnecessary, however, to give in detail the further results obtained from it.

G. M.

January, 1909.

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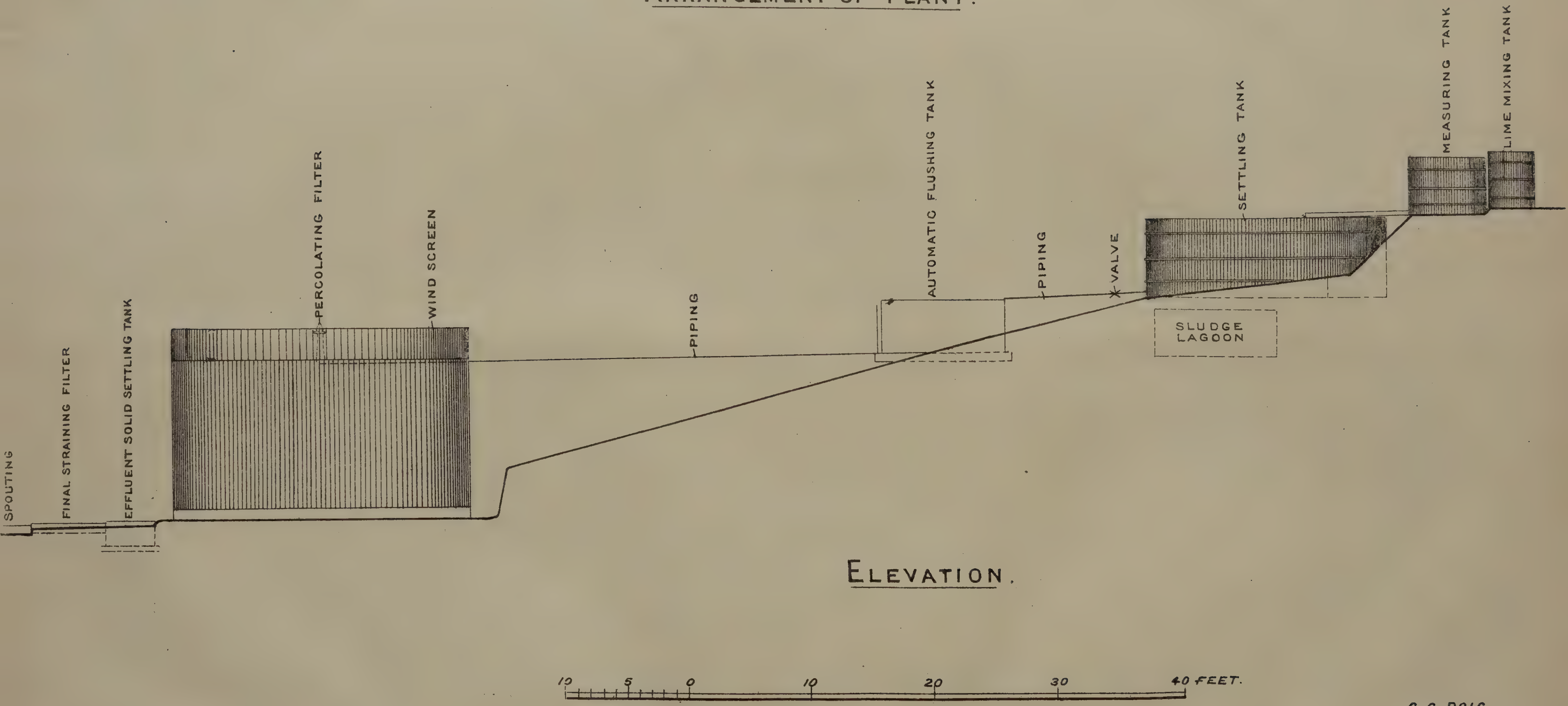
* The percentage of nitrogen will be determined.

† During these four days, the unfiltered liquid had of course been fermenting.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

DISTILLERY WASTE LIQUIDS.

ARRANGEMENT OF PLANT.



ELEVATION.

C. C. DOIG.
ELGIN.

2082. 2. 08.

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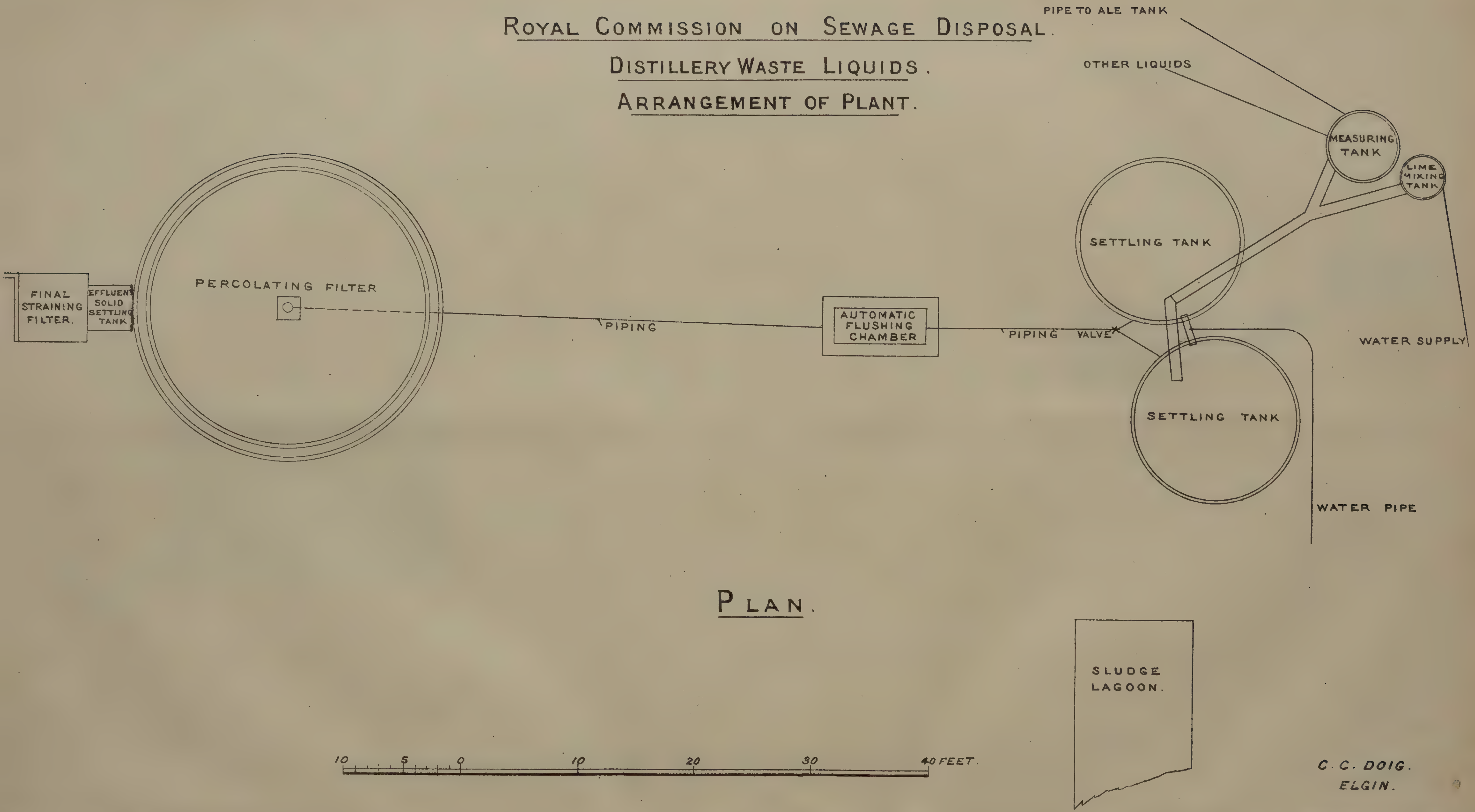
ROYAL COMMISSION ON SEWAGE DISPOSAL.

DISTILLERY WASTE LIQUIDS.

ARRANGEMENT OF PLANT.



PLAN.

C. C. DOIG.
ELGIN.

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APPENDIX II.

REPORT BY MR. R. D. LITTLEFIELD ON THE TREATMENT OF DISTILLERY WASTE LIQUIDS.

SECTION I.

Purification of Waste Liquors on Percolating Filters.

The experimental investigations of the Commission in regard to distillery waste were commenced in February, 1906. Prior to this, in the year 1901, Professor Hendrick of Marischal College, Aberdeen, had published a paper* giving the results of experiments on the purification of distillery waste liquors, from which he showed that these were amenable to biological purification, after liming and settling. In the early summer of 1903, Dr. G. McGowan, chief chemist to the Commission, made some experiments upon the bacteriological purification of pot-ale on the laboratory scale, and the results he obtained led him to suggest to the Commission (Memorandum of October, 1903)† that a modified form of sewage treatment applied to distillery waste liquids, and properly controlled, might be expected to produce a satisfactory effluent.

The Commission decided that the treatment of distillery waste liquids on the lines suggested by Dr. McGowan was worthy of a trial on a practical scale, and they invited the North of Scotland Malt Distillers' Association to co-operate with them by erecting a plant at some suitable distillery. The outcome of the negotiations was that certain members of the Association pledged themselves to provide sufficient funds for the erection of a plant on a scale large enough to allow of the results being of real and practical value. The Commission were fortunate to have offered them an excellent site for the plant and a well equipped laboratory at the Coleburn distillery by Messrs. Robertson and Sons, Limited, of Dundee and Coleburn.

The whole arrangement of the plant was settled by the Commission. The plant was designed by Mr. C. C. Frye, in consultation with the other Officers of the Commission, and its erection was entrusted on behalf of the Distillers' Association to Mr. Doig, C.E., Elgin, and to myself, acting for the Commission.

The guiding principle acted upon by the Commission was that the whole of the waste liquors of a distillery, in the proportions in which those several liquors naturally occur, should be treated.

The effluent which they aimed at producing was one which would not :—

(1) Appreciably de-oxygenate the water of a stream ;

(2) Be injurious to fish ;

(3) Cause the production of objectionable or fungoid growths in a stream ;

(4) Render the water of a stream unfit for domestic use.

The site placed at the Commission's disposal at Coleburn distillery by Messrs. J. Robertson and Son, Limited, was admirable in all respects excepting for its exposed position during strong northerly winds. The distillery is about six miles from Elgin in the Rothes Valley. The soil is a sandy gravel, and the Cole burn, a small stream, flows through the property.

The chief items of the plant comprised :—

(1) A tank for measuring the volumes of the various waste liquors to be treated ;

(2) A tank for making and discharging milk of lime ;

(3) Two large settling tanks, each of 6,000 gallons capacity, provided with sludge valves discharging into a sludge lagoon, and fitted with floating arms for the purpose of drawing off clear supernatant liquor ;

(4) An automatic flushing chamber, capable of discharging any measured quantity up to 100 gallons ;

(5) A circular percolating filter, 24 feet in diameter and 12 feet deep, filled with gas-works coke of good quality, in pieces varying from one inch to three inches in diameter. The filter contained sixty-eight tons of coke and had a capacity of 200 cube yards. The coke rested on a false bottom of perforated bricks and the whole stood on a slightly convex foundation of concrete. The filter was fitted with an automatic revolving sprinkler, which was protected by a wind screen standing 2 feet 6 inches above the top of the coke.

(6) A small tank for the settlement of the bulk of the effluent solids—followed by three small straining filters, used separately. The tank was fitted with a valve and could be sludged at will. The straining filters consisted of three inches of gravel, on the top of which was about an inch of graded sand ;

(7) A very shallow sludge lagoon with sloping concrete bottom, 30 feet by 10 feet by 6 inches deep, banked round with sand. On the bottom was placed a thin layer of sand and gravel. The lagoon drained into a sump from which the liquid was pumped back into the settling tanks.

The sketch-plans inserted show the arrangement of the scheme.

The works were completed early in May, 1906. The maturing of the filter was commenced at once, the filter being sprinkled, on alternate days, with 200 to 300 gallons of a mixture of pot-ale and water (1 part and 2·5 parts respectively). At the same time occasional doses of a solution containing the nitrifying organisms from soil were given. This solution was prepared by extracting with water a thin layer of the soil immediately underneath some patches of dried cow dung. The maturing process was then carefully continued by the addition of moderate doses of diluted pot-ale in sufficient quantity to yield an effluent.

By analysing this effluent daily, one was able to control the amount of organic matter put on the filter, so that at no time was it overworked.

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* *Journ. Soc. Chem. Ind.*, May, 1901. † *See* Appendix I.

The liquid treated during the period June to September, 1906, consisted of a mixture of one part of pot-ale and nine parts of water, limed and settled. Up to 20th September, 1906, the total amount treated was 11,500 gallons of pot-ale, this period including all the time spent in maturing the filter. Starting with thirty gallons of pot-ale, *i.e.*, 300 gallons of limed liquor per 24 hours, on the filter, on 20th June, 1906, the final dose during the last week of the work, 13th to 20th September, 1906—after which the supply of pot-ale was exhausted—amounted to 530 gallons pot-ale, *i.e.*, 5,300 gallons of limed liquor, per day. It is possible that the time taken in maturing the filter, so that it might successfully treat a daily dose of 5,000 gallons of limed liquor, might have been considerably lessened. The progress of the experiment with this limed liquor was, however, temporarily interrupted by an attempt to treat a limed liquor of twice the strength. Analysis of the effluents obtained showed that this latter liquid—one part pot-ale and four parts water, limed and settled—was too strong for the filter, at all events for the filter in its then state of maturity; this experiment was therefore stopped. Incidentally it showed that the filter, like a sewage filter, was able to recover its efficiency by resting and being kept just moist. In this case fourteen days rest was given, after which the filter resumed its treatment of the 10 per cent. liquor, with the production of a good effluent.

During the period under review—up to 20th September, 1906,—the liquor being treated gave an average figure of 86 parts per 100,000 for "oxygen absorbed" from $\frac{N}{8}$ permanganate in four hours at 27 C. The corresponding figure for the effluent was 2 parts per 100,000.

From 25th September to 25th October, 1906, the filter treated undiluted limed steep water at the rate of about 1,100 gallons per day—the whole output of the distillery. It could have easily dealt with a much larger volume of this, probably at least three or four times the amount. This separate treatment of steep liquor was interesting, as showing the excellent purification obtainable with such a filter. The four hours "oxygen absorbed" figure for the limed steep water averaged 57·7 parts per 100,000—that of the effluent from it, after removal of suspended solids, 1·6 per 100,000.

In November, 1906, pot-ale again became available, and from this time to 20th June, 1907, the filter was daily dosed with a liquor composed of 400 gallons pot-ale and about 1,000 gallons of steep water and other distillery waste liquids, the whole diluted to 4,000 gallons, limed and settled. This was, therefore, equivalent to two gallons of pot-ale plus 4·5 gallons of the other mixed waste liquors per cube yard of filter per day, being approximately the ratio in which the various liquors were actually produced at the distillery.

As the situation of the plant was an exposed one it was deemed advisable, in October, 1906, to be prepared for hard frosts, since any prolonged period of severe weather might seriously interfere with the continuous working of the process. To provide against this, each of the two settling tanks was fitted with about 80 feet of 2-inch cast iron pipes, connected with a slow combustion stove and boiler, similar to that used in an ordinary greenhouse hot-water apparatus. It so happened that the winter of 1906–7 was a severe one, but the heating apparatus enabled the plant to be kept working almost continuously. Had it not been that the effluent froze under the filter and formed a solid mass of ice which choked the perforated bottom, working could have been continuous. In erecting another plant on these lines, such an eventuality could be provided against by having the effluent channel from the filter less exposed.

The subsequent experience, however, of the season 1907–8 showed that the best way of ensuring the continuous working of such a filter is to cover in the top. This makes artificial heating unnecessary. The cover in this case consisted of a flat roof of half-inch boarding, 2 feet 6 inches above the top of the coke, *i.e.*, flush with the top of the wind screen. At the same time the base of the filter was protected against cold winds and drifting snow by means of broom hurdles.

I need only refer to the Tables in Appendix V, where a record of the purification effected will be found. It will be seen that the efforts to keep a liquor of constant strength going on to the filter were fairly successful, and that a high class effluent was almost uniformly produced.

Method of Working the Process.

Throughout the experiments the plan of making up the liquor to be treated was as follows :—

From the distillery storage tanks, measured quantities of the pot-ale and the other waste liquors were run into one of the settling tanks and then diluted with a portion of the water to be used. The proper quantity of milk of lime was then added from the lime-mixing tank, and the whole was made up with further water to ten times the volume of the original pot-ale. The amount of lime required varied with its quality and with the acidity of the pot-ale, this acidity increasing with age. Roughly speaking, 30 lbs. of the lime of the district (approximately 50 per cent. CaO) were usually sufficient for 1,000 gallons of pot-ale plus the other liquors. There is no difficulty in telling when sufficient milk of lime has been added, as the change in colour of the liquid, produced by a slight excess of lime, is so marked that but little practice is necessary to hit the right proportion. A distinct excess of lime over that required to render the liquid neutral is necessary. On the other hand, any further excess merely means unnecessary expenditure.

Usually twelve hours quiescent settlement after thorough mixing was given, though considerably less than this would suffice; probably about four hours would be enough. The settled liquor was drawn off continuously by means of a floating arm into the automatic flushing tank. The latter was so constructed that it could discharge from 5 gallons to 100 gallons as required. At the rate of working followed through the experiment, *i.e.*, twenty gallons of precipitation liquor per cube yard per twenty-four hours, it discharged fifty-six gallons every twenty minutes, the flush lasting four minutes. The feed was thus an intermittent one. Owing to the depth of the filter, however, there was but little variation in the rate at which the effluent flowed out at the bottom.

The effluent flowed into the small settling tank (capacity 120 gallons), where it received forty minutes continuous flow settlement, and then through the small straining filter. For convenience sake the latter was divided into three sections, of which two were always in use. The straining filter was constructed of wood throughout, and the sections were each 6 feet square. The filtering material consisted of 3 inches of small gravel, covered with ½ inch of coarse sharp sand and a top layer of ½ inch of fine sharp sand. The rate of working on this filter amounted to 500 gallons per square yard per day. During the first year of working, when but few solids issued from the percolating filter, it was only necessary to scrape the straining filter once in three to four weeks. During the second year, however, when an average of probably about four parts per 100,000 were issuing from the percolating filter and about two parts from the effluent settling tank, the straining filter required scraping every week or ten days, and more frequently during the "Spring out-flush" of solids from the percolating filter. The scraping was done when the filter was wet, and consisted in the removal of the top layer of the clogged fine sand with a small hoe. The effluent settling tank was sludged twice a week.

Sludging of the Precipitation Tanks.

The precipitation tanks were sludged after three fillings, *i.e.*, each was sludged once a week. Even in warm weather it was not necessary to sludge more frequently, and there was never any nuisance from smell. From 80 to 100 gallons of thin sludge were run from each tank weekly into the sludge lagoon, described above. Here the sludge drained rapidly, and no difficulty was experienced in removing it by spade, even in wet weather. There was usually a slight smell from the lagoon, but it was practically negligible.

One thousand gallons of pot-ale, together with the corresponding proportions of the other waste liquors, produced about one cwt. of air-dried sludge.

It is important to note here that the air-dried sludge could be readily passed through a $\frac{1}{4}$-inch sieve, after which it was in excellent condition for use as manure. An analysis of a good average sample gave the following figures :—

	Per cent.	
Moisture at 105° C.	29·13	=100·0
Volatile matter	6·74	
Non-volatile matter (chiefly sand, with some lime)	64·13	
Tri-calcium phosphate, $Ca_3(PO_4)_2$	5·77	
Total nitrogen by Kjeldahl method	0·80	

Filter Effluent.

During the first year of the work, 1906–7, the limed liquor, prior to treatment on the filter, was a somewhat opalescent and pale yellow liquid, with hardly any visible suspended solids, and with a clean brewery smell. Its specific gravity varied from 1000·83 to 1001·82. If kept for a day or two, it soon soured and acquired a very nauseous smell. Freshly made, it was always distinctly alkaline and frothed most persistently. The filter effluent, on the other hand, was a bright, non-opalescent liquid of a very pale straw colour, with varying amounts of dark brown granular suspended solids ; it did not froth on shaking. Detailed analyses of both these liquors are to be found in Appendix V. The following figures give an idea of their average composition :—

Parts per 100,000.	Limed Liquor.	Effluent.
Ammoniacal nitrogen	0·69	0·12
Albuminoid nitrogen	5·61	0·28
Oxygen absorbed from $\frac{N}{8}$ permanganate in 4 hours at 27° C.	92·0	2·61
Solids in suspension	—	Traces.
Nitrous nitrogen	—	0·0
Nitric nitrogen	—	1·12
Alkalinity,* expressed in parts CaO per 100,000	—	15·80
Dissolved oxygen taken up from water in 5 days at 27° C.	—	0·59

In the season 1907–8, during which time the salmon-hatching and rearing experiments, detailed in Appendix IV, were being carried out, the liquor treated on the filter consisted of pot-ale diluted with water, limed and settled. The daily dose amounted to 4,000 gallons of limed liquor (equivalent to 330 gallons of pot-ale), and this dose was maintained continuously from 1st December, 1907, to 24th June, 1908.

The quality of the final effluent (from the straining filter) during this period varied but little. The average of a large number of analyses gave the following figures :—

Ammoniacal Nitrogen	0·03	parts per 100,000.
Albuminoid Nitrogen	0·14	,, ,,
Total Organic Nitrogen	0·36	,, ,,
Nitrous Nitrogen	0·01	,, ,,
Nitric Nitrogen	0·66	,, ,,
Total Nitrogen	1·13	,, ,,
Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C. *at once*	0·43	,, ,,
Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C. *in 4 hours*	1·75	,, ,,
Dissolved oxygen taken up from water in 48 hours at 27° C.	0·30	,, ,,
Dissolved oxygen taken up from water in 5 days at 27° C.	0·74	,, ,,
Oxygen in solution when analysed	0·80	,, ,,
Oxygen remaining in solution after incubation for 5 days at 27° C.	0·43	,, ,,
Alkalinity (expressed as CaO)	12·50	,, ,,
Solids in suspension	less than 1·0	,, ,,

The effluent was invariably non-putrescent upon incubation.

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* NOTE.—The alkalinity of the effluent was due to carbonates.

Suspended Solids in Effluent.

The filter began to work on 20th June, 1906, and ran practically withou intermission until 1st July, 1907. It was then rested until 1st November, 1907.

During the first six months the effluent was practically free from suspended solids. After this the amount averaged about one part per 100,000, excepting at the period of the "Spring out-flush," when it rose to three to six parts. Similarly, if the filter was rested for a day, there was a considerable increase in the amount of solids washed out for a few hours after re-starting. It may be taken, however, that up to April, 1908, the solids washing out of the filter did not amount on the average to more than two parts per 100,000. From April to July, 1908, very much larger amounts came out in the effluent. No doubt this was due to the increased activity of the worms, fly larvæ, etc., in the filter during the warmer weather. It was also noteworthy that the effluent settling tank was frequently covered with a layer of small grey aquatic insects in this warm weather.

The effluent solids consisted of broken down organic matter, together with living and dead worms, fly larvæ, etc., and were necessarily putrescible, though not very quickly so. It is, therefore, desirable that those solids should be removed before the effluent reaches a water course, in some such manner as has been already indicated.

A sample of these solids, collected over a week, gave on analysis the following figures. The mud was first dried at 105° C.

Organic matter, etc.	74·2 per cent.
Alumina and ferric oxide	10·8 „ „
Lime	10·0 „ „
Siliceous matter	4·6 „ „
	99·6

Condition of the Material on the Top of the Filter.

For the first six months the coke on the top of the filter remained quite clean. Afterwards more or less slimy growths appeared and flourished. These growths consisted of practically a pure culture of the humus flora, *Fusoma parasiticum*, though another fungus, *Chlamydomucor racemosus*, was also present. They were identified by the Authorities at Kew Gardens, in whose opinion the spores of the growths, which are evidently abundant, find their way into the liquid treated, either conveyed by wind, or by surface drainage into the water supply. So long as the growths did not clog the filter top sufficiently to cause serious ponding, no bad effect on the effluent was observed; but when the distribution of the limed liquor on the filter became seriously impaired by these surface growths, the effluent deteriorated. It was, therefore, necessary to get rid of the growths from time to time. Three methods of removal were tried. The first consisted in simply forking up the top, resting the filter and allowing the sun and air to dry up the growths. The disadvantages of this method are the time required and the dependence on the weather. The second method consisted in lightly removing the top 3 inches of the filter, which carries all the growth, and immediately replacing it with clean coke. The portion removed, after being allowed to weather in the open for a short time, can be easily washed clean on a screen and is then available for use again. The third method was a chemical one, on the lines first proposed by Dr. A. C. Houston and Mr. C. C. Frye. Experiments with various reagents at the Commission's Experimental installation at the Dorking Sewage Works had shown that a 20 per cent. solution of caustic soda was very effective in removing such growths. After allowing the Coleburn filter to drain, a 20 per cent. solution of caustic soda was sprinkled, hot, evenly over the top of it. Fourteen pounds of soda was used altogether, being at the rate of 1 lb. of soda to three square yards. The effect of this was to dissolve the growths slowly; after forty-eight hours the surface was clear of them, while on re-starting the filter the effluent had not deteriorated in any way. The alkali was all washed out in about eight hours. This process possesses these advantages; the soda is easily applied, the coke is not disturbed or broken down, and the filter is cleared of a very large amount of semi-solid organic matter, which is disintegrated and washed through.

Of the three methods just described, the second will be probably found the most efficient and economical.

In practice it will be found necessary to remove the growths from such a filter treating distillery liquids by one or other of the above methods, every five or six weeks in mild weather—not so frequently in cold.

Channel Experiments with the Effluent from the Coleburn Filter.

It is the production of grey growth in streams receiving waste liquors from distilleries that is most objected to by riparian owners, not only on account of its unsightliness, and the injury it occasions to fish and fishing, but also because of the nauseous smell which is produced when the fungus decays and putrefies during the summer months.

It was thus very important to determine by direct experiment the nature and amount of the growths which would be produced by such an effluent as that from the Coleburn filter. This was done at the suggestion of Mr. F. J. Willis, by constructing several artificial V-shaped wooden channels, supported clear of the ground and 210 yards in length. They were arranged with a continuous fall and an occasional drop, fall and drop together being ten feet over the whole length, and were zig-zagged. In the bottom of the troughs clean gravel and sand was placed and, at intervals, pieces of turf, twigs, etc., so as to imitate the conditions of a natural stream as closely as possible. There were three channels in this experiment. They ultimately discharged their liquids into a natural ditch, some 350 yards in length, which carried a little surface water from neighbouring land and eventually entered the Cole burn. Channel No. I. carried the effluent from the filter undiluted, No. II. the effluent diluted with an approximately equal volume of water, whilst No. III carried water alone. The channels were placed side by side and were kept running continuously for twelve months, July, 1906 to July 1907.

For the first six weeks of the experiment only a faint tinge of minute green growths appeared on the stones. This gradually increased, and when the growths became large enough, about six months after starting, samples were taken and sent to the Royal Gardens, Kew, for identification. The weeds in Channel No. I. were then a little greater in amount than in Channel No. II. and this difference persisted throughout the twelve months. Roughly speaking, Channel No. I. showed weeds half as far again along its length as No. II. The growth from both the channels was green, and was identified as chiefly consisting of *Rhizoclonium hieroglyphicum*, but there were also small quantities of other harmless and well known fresh water algæ, notably two varieties of the *Spirogyra* and *Microspora amoena* and *abbreviata* and *Chaetormorpha sutoria*. In Channel III. the growths were rather less, both in luxuriance and extent, than in the effluent channels, and consisted of the varieties of green filamentous algæ typical of a moorland surface water. *Rhizoclonium hieroglyphicum* was not observed amongst the growths in this channel.

Subsequent examinations made from time to time have always shown similar growths, and on no occasion during the period under review has the slightest trace of any grey growth, *e.g.*, sewage fungus, *Apodya lactea*, been observed.

The ditch into which both effluents from Channels No. I. and II. flowed was one which would have lent itself readily to the growth of grey fungus, had there been the necessary pollution. Its banks were steep and overhanging, the water was comparatively stagnant, and the ditch received drainage from agricultural land. Notwithstanding this, no traces of grey growths were observed in it. Careful examination only revealed the presence of growths similar to those occurring in Channel No. III., which carried water alone.

Under these conditions one could not expect to find any evidences of pollution where the ditch joined the Cole burn—nor were there any. Too much stress can hardly be laid on the value of this experiment. The channels and the ditch together presented all the natural conditions of a burn, and the test was a severe one, in that the dilution of the effluent was very small. In every case in practice the effluent would flow into a stream of larger volume than the effluent.

Costs.

As regards the capital and working costs of such a purification plant as the experimental plant at Coleburn, only approximate estimates can be given here, as the conditions of site, railway facility, cost of material and sundry other items vary in different localities. The following figures, however, relating to the plant at Coleburn, will be of some assistance in the matter.

This plant may be regarded as sufficient to deal with 2,500 gallons of pot-ale plus 7,000 gallons of the other waste liquids per week of six days. The capital cost amounted to £250.

Working expenses :—	£	s.	d.
Labour—40 weeks at £1 per week	40	0	0
Lime—2½ tons at £1 (at works)	2	10	0

Suppose these figures are applied to a hypothetical distillery which mashes 1,000 bushels of malt per week. Here we shall have a production of, say, 12,000 gallons of pot-ale per week, together with the other waste liquors in the proportions already stated. The working of the plant has shown that 2 gallons of pot-ale plus the proportional volumes of the other liquids can be successfully treated per cube yard of filter per day. Working six days in the week gives 2,000 gallons of pot ale to be treated daily, which, therefore, requires 1,000 cube yards of filter.

Supposing the capital outlay to be on the same scale as at Coleburn, a plant of five times the size would be necessary, and we should require a sum of £1,250.

Taking working expenses :—	£	s.	d.
One man—40 weeks at 20s.	40	0	0
Lime—12 tons at 20s.	12	0	0
Depreciation 5 per cent	62	10	0
Interest on capital 4 per cent.	50	0	0
Technical supervision	50	0	0
Total	214	10	0

As a set-off against this there would be produced about twenty tons of manure worth 30s. a ton,* say £30, leaving a net cost of £184 10s. a year.

A distillery using 1,000 bushels of good barley would produce about 2,400 gallons of whisky per week. Allowing one half-penny per gallon of whisky as a charge for the disposal of waste liquors, this amounts to £5 per week, or £200, for a season of forty weeks working.

I am assured by distillers generally that any scheme which satisfactorily disposes of waste liquors at a cost of under one penny per gallon of whisky produced would be commercially possible, and not an undue restriction upon trade. From conversations with a number of them, the cost of other purification processes at present in use varies from about three farthings to twopence or even threepence per gallon of whisky. It will be noticed that a charge for technical supervision is included in the above expenses of working. In dealing with such a process as has been described, periodical expert advice and supervision is a necessity. Subject to this, the working of the plant can be successfully carried on by an intelligent and trustworthy workman.

In November, 1908, that is, since the above estimate of the probable cost of a plant was made, the Craigellachie-Glenlivet Distillery Co. has accepted a tender for the erection of a complete plant to treat the whole of the waste products from their distillery—when dealing with 1,500 bushels of malt per week. The plant is designed on the lines of the Commission's experiments at Coleburn and the total amount of the accepted tenders is, in round figures, £1,880.

Further Channel Experiments.

In addition to the experimental channels dealing with the effluent from the percolating filter at Coleburn, just described, various others were made, viz., channels carrying the following dilutions of pot-ale :—

(*a*) One volume pot-ale in 1,000 volumes of water.
(*b*) „ „ 2,000 „ „
(*c*) „ „ 4,000 „ „
(*d*) „ „ 6,000 „ „
(*e*) „ „ 8,000 „ „
(*f*) „ „ 10,000 „ „

Of these (*a*), (*b*) and (*c*) produced luxuriant sewage fungus and other grey growths in from three to six days, while (*d*) and (*e*) showed similar fungus in a fortnight and three weeks respectively.

Channel (*f*) was kept running for a year, and only on two or three occasions were minute traces of sewage fungus discovered. It would thus seem that a dilution of 10,000 volumes is about the limit at which a mixture of pot ale and water will not produce any visible quantity of fungus.

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* *See* Mr. Macadam's Report, Appendix VI.

It should be pointed out here that in these channel experiments it was a practical necessity to dilute the pot-ale in the first instance (either a 5 per cent. or 10 per cent. solution was used), before discharging it into the channel. If undiluted pot-ale were discharged into a stream 10,000 times its volume, there can be very little doubt that fungus would appear in the immediate vicinity of the discharge. Pot-ale, being a heavy liquid, does not mix very readily with water.

Further channels (*g*) and (*h*) were constructed—in (*g*) a 10 per cent. solution of pot-ale was running, in (*h*) a similar liquid, save that it had been treated with excess of lime and settled. It was thought that the removal of the greater bulk of the phosphate in the pot-ale might lessen the production of fungus. This, however, did not prove to be the case, for luxuriant growths of fungus appeared in both channels ; the only difference was that in the limed channel (*h*) the initial growths had a mauve tint, which disappeared in the course of a few days.

It should be added that, though about nine-tenths of the phosphate of pot-ale are removed by liming and settling, sufficient remained in the above liquid—which was still a very strong one organically, something like four times as strong as an ordinary crude sewage—to give abundant nutriment for growths.

Channel (*j*).—In this an experiment was made with the effluent from the contact bed system in use at Coleburn distillery.

Under this system, roughly speaking, equal volumes of pot-ale and other waste liquors were limed and the settled liquor run on to contact beds. The effluent from the last bed was still very impure organically, having a four hours "oxygen absorbed" figure of about 60 to 65 parts per 100,000, and a foul smell. It was diluted with 1,000 volumes of water and the mixture run through channel (*j*). Green algae appeared in the channel in two to three days and were very luxuriant in three weeks. At this time grey growths also appeared, mingled with the green, though not in great amount. It has to be borne in mind, when considering the abundant green growth of channel (*j*), that the liquid in this channel, though organically weaker than, for example, that in channel (*e*), contained relatively much more inorganic manurial plant food.

The figures for Ammoniacal and Albuminoid Nitrogen in the above contact bed effluent varied from 3 to 4 and 7 to 8 parts per 100,000, respectively.

The foregoing experiments have all been made with dilutions of pot-ale or liquids derived from pot-ale. That steep liquor alone will also give rise to grey growths is shown by the following laboratory experiment. In this experiment a steep water of medium strength was allowed to trickle into a large basin having gravel and sand in the bottom and turf round the sides, and through which a stream of water twenty times the volume of steep liquor was passing. Sewage fungus appeared in ten days and rapidly increased.

A similar experiment, but with a dilution of forty volumes, showed fungus in fifteen days. This fungus also rapidly increased.

No direct experiments have been made for the Commission with the other waste liquors, but an instance came to my notice at a distillery where the drainings from the wet "draff" ran into a small ditch, and produced fungus in it. At my request the distiller caused the drainings to be diverted to his pot-ale-receiving-tank, after which the ditch soon became clean.

Growths from Channels.

The following chemical analyses of pressed growths taken from various streams in March, 1907, were made. These afford interesting evidence as to the nature of the nutrient matter required for their development, and also show why it is that some of them give rise to such an offensive odour when putrefying.

The analyses were made on the samples after they had been cleaned as carefully as possible from worms and animalculæ, by washing very small portions at a time, and then pressed between filter paper.

I. *Sample of ordinary mixed fungoid growths, chiefly Leptomitus lacteus, taken from a dam polluted with distillery waste liquors.* The cleaned and pressed sample contained 71 per cent. of moisture, and in this condition took up 4.93 per cent. of oxygen from $\frac{N}{8}$ permanganate in 4 hours at 27° C. One gramme of the pressed weed was put in a stoppered bottle along with 340 c.c. of well aerated tap-water (8.12 c.c. oxygen per litre), the bottle being filled completely, and kept at laboratory temperature. At the end of seven days the whole had a most foul smell, like that of decomposing animal matter.

Again, 0·4 gramme and 0·5 gramme in 585 c.c. and 616 c.c. of equally well aerated tap-waters were kept under similar conditions. At the end of 46 days the solid matter in both bottles was very black, and the contents were putrid and smelt strongly of sulphuretted hydrogen.

Another sample of similar mixed fungoid growths, after washing and pressing, gave the following figures :—

Moisture	79·6	per cent.
Volatile Matter	14·0	,,
Non-Volatile Matter	6·4	,,
	100·0	,,
Total Nitrogen	0·59	,,
Oxygen absorbed from $\frac{N}{8}$ permanganate in 4 hours at 27° C.	3·18	,,

II. *Sample of growth from a channel along which the effluent from the Coleburn filter was flowing.* The growth consisted mainly of *Rhizoclonium hieroglyphicum.* The cleaned and pressed sample gave the following figures, on analysis :—

Moisture	79·7	per cent.
Volatile Matter	10·0	,,
Non-Volatile Matter	10·3	,,
	100·0	,,
Oxygen absorbed from $\frac{N}{8}$ permanganate in 4 hours at 27° C.	3·42	,,

One gramme of the pressed weed in 346 c.c. of well aerated tap-water was incubated, as before, at laboratory temperature. In 17 days the solid matter was blackened, and the mixture was putrid and smelt of sulphuretted hydrogen. In a second similar experiment 0·59 gramme of the weed in 625 c.c. of tap-water was incubated for 43 days, by which time the weed had blackened and the mixture was putrid.

III. *Sample of growths taken from a channel along which ordinary burn water alone was flowing.* This was the typical bright green vegetation seen in the streams of the district, which comprised several members of the *Chlorophyceæ* group of fresh water algae. The cleaned and pressed weed gave the figures :—

Moisture	80·6	per cent.
Volatile Matter	16·5	„
Non-Volatile Matter	2·9	„
	100·0	„
Oxygen absorbed from $\frac{N}{8}$ permanganate in 4 hours at 27° C.	4·08	„

One gramme was incubated as before with 620 c.c. of tap-water ; at the end of 15 days the mixture was rather turbid and putrid, with much sulphuretted hydrogen. A similar incubation of 1·37 grammes in 620 c.c. of tap-water for 42 days yielded a strongly putrid mixture and much sulphuretted hydrogen.

The following Table gives the partial analysis of other typical samples of those growths, side by side. The samples were first cleansed and washed very carefully and then pressed between filter paper.

	Fungoid growths from a polluted burn (grey growths).		Green growths in Coleburn effluent channel (chiefly *Rhizoclonium hieroglyphicum*).	Green algae from unpolluted burn.	
	June 16th, 1907.	June 15th, 1908.	June 16th, 1907.	June 16th, 1907.	June 16th, 1908.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	82·69	81.5	70·26	78·19	72·1
Volatile Matter	13·97	16·40	27·15	19·92	22·6
Non-Volatile Matter	3·34	2·1	2·59	1·89	5·3
	100·00	100·00	100·00	100·00	100·00
	Calculated on the weed dried at 105°C. Per cent.				
Total Nitrogen	–	6·78	–	–	3·23
Total Sulphur (S_2)	0·64	0·64	1·21	0·57	1·48
Sulphur (as SO_3) extracted in the cold by 1°/₀ HCl in 24 hours	0·21	–	0·33	0·72	–
Total Phosphorus (P_4)	1·66	1·32	0·72	0·24	0·49
Phosphorus (as P_2O_5) extracted in the cold by 1°/₀ HCl in 24 hours	2·56	–	0·77	0·30	–
Siliceous Matter	12·70	1·18	3·87	–	11·63

In concluding this section of the report, I should like to express my great indebtedness to Mr. Robert Shanks for the assistance which he gave me in connection with the Coleburn experiments. As the Commission are aware, he was employed on the work during the whole time the experiments were in progress, and he spared neither time nor pains to make them a success, so far as he himself was concerned.

Rivers and Streams.

The time at my disposal has not permitted a very thorough examination of the rivers and streams in the district. Particular attention, however, has been given to the Cole burn, and also to the Dullan and the Fiddich, on account of the Commission's experiments close to those rivers. Stretches of the River Spey, too, have been examined occasionally, and the condition of several other streams has been noted, when describing the distillery nearest to one or other of them.

During 1906 and 1907 I made a number of visits to various parts of the River Spey and its tributaries the Livet and Avon, but never observed sewage fungus in the rivers themselves. There were no more vegetable growths than one might reasonably expect to find in a clean river, nor was there any frothing beyond what is generally noticeable in peaty streams. The fishermen with whom I spoke at the time were generally agreed that these waters were in good condition.

The heavy rainfalls which occur from time to time in the district result in more or less severe spates, which exercise a powerful scouring effect on the bed of a stream, cleansing it in this way from growths of all kinds.

Small amounts of grey growths occur in almost all streams, and it is probably correct to say that practically all streams receive at least some traces of unoxidized organic matter. Speaking broadly, however, the character of the predominating vegetable growths in a stream furnishes a good indication of the nature of the water.

Grey fungoid growths indicate more or less pollution, according to their abundance; some growths of the Chlorophyceae genus indicate a water richer in nitrogenous constituents than a pure burn water, while others flourish in a pure burn water. One instance, showing that a general knowledge of the growths occurring in moorland streams is of considerable advantage, occurred recently, when a growth known as *Gomphonema geminatum* was taken to be sewage fungus, and accusations of pollution were made against a near distillery. This growth is typical of sub-alpine streams, and is a greyish-white felt-like mass, which to the uninitiated would look something like *leptomitus lacteus.*

It is generally recognised in the district that a red coloration on the stones in the bed of a stream is an indication of pot-ale pollution. This is no doubt the case when the pot-ale percolates through soil before reaching a stream, but whether it necessarily shows the direct pollution of water by pot-ale seems doubtful. In many places there are chalybeate springs which find their way into streams, carrying dissolved and finely divided iron compounds with them. It is not unreasonable to suppose that more or less of this iron would gradually be absorbed by the more porous of the stones forming the river bed. In the days when distillery waste liquors were generally pumped into holes in the ground, their acid would dissolve iron from the soil, giving rise to an artificial chalybeate water.

A great number of visits have been made to the rivers Dullan and Fiddich, in close proximity to which there are seven distilleries. Both these rivers are good trout streams and in the late summer salmon are also caught. On no occasion have I observed any evidences of real pollution in the River Dullan. Some portions of the River Fiddich were not so clean, and occasionally the fungoid growths were present in sufficient quantity to be regarded as a serious nuisance.

The observations on the Cole burn, which at Coleburn distillery is only a small stream, have been interesting mainly on account of the fact that the effluent from the Commission's experimental plant ultimately found its way into it. This effluent has been described when dealing with the working of the plant, and it only remains to be said that no sign whatever of pollution has appeared in the stream receiving it. Indeed the strongest evidence of the harmless nature of the effluent is afforded by the observations made in the natural ditch which conveyed it to the burn. In this ditch the weeds were precisely similar to those growing in the dam which supplies water to the farm.

Disposal of Pot Ale on Land.

Seeing that pot-ale contains about 0·1 per cent. nitrogen, 0·2 per cent. phosphoric acid, and 0·15 per cent. potash,* its disposal upon land, where this is practicable, seems to be the natural method of purifying and at the same time utilising it. Such a method of disposal, however, demands a sufficient area of suitable land and proper facilities for distributing the pot-ale over it. We do, in fact, find that more or less pot-ale is got rid of in this way at many distilleries—good examples of this being Glenlivet and Mortlach. At both of these places, although the soil is naturally rather poor and shallow, good results as regards purification and cropping are obtained by careful management.

The volume of pot-ale which can be treated upon an acre of land naturally depends mainly on the nature and depth of the soil and subsoil. As is well known, the purification of sewage by land is largely dependent upon its proper distribution; and seeing that pot-ale is organically about forty to fifty times stronger than ordinary sewage, the necessity for the best possible distribution is obvious. At Glenlivet, where there is a large area of gently sloping land, but with a shallow soil of poor quality, 15,000 to 20,000 gallons of settled pot-ale per week were distributed on a twenty-acre field for five weeks in succession, in April and May, 1907. This is equivalent to 125 to 166 gallons per acre per day, during that period. An analysis of the drainage water from this, made on May 8th, 1907, showed that adequate purification had been effected. There are not sufficient data to say how long this area would have continued to purify this volume of pot-ale, but it may probably be taken that land of the above qnality, which is more or less typical of the district, provided it received a dressing of lime at intervals, would purify an average of 100 gallons of pot-ale per acre per day over a whole season.

Since in a practical land treatment scheme, pot-ale would probably be distributed on farm land, it is obvious that a much larger total area than that just indicated would be required, in order to allow for rotation of crops, etc.

Good deep loam would, of course, be capable of purifying a larger volume. With regard to soil of good or medium quality, overlying gravel and sand, this would take more pot-ale than poor soil upon pan or rock. But since gravel and sand are usually close to a stream, great care would have to be taken in such a case to avoid overdosing, otherwise imperfectly purified effluent would quickly reach the river and give rise to grey growths. Peat land is unsuitable for the purification of pot-ale, by reason of its spongy and acid nature. Land which is permeated by springs is also to be avoided. Where land is to be used for the treatment of pot-ale, it ought to receive small dressings of lime at fairly frequent intervals. This will prevent the land from souring and will greatly facilitate purification.

The chief reasons why larger quantities of pot-ale are not carted on to land are (1) the difficulty frequently experienced in getting suitable land at a reasonable price and (2) the cost of carting. There are instances, notably at Mortlach distillery and Dailuaine distillery, where the proprietors have gone to great expense in laying pipes, by means of which the pot-ale can be pumped to outlying districts where land is available and cartage less expensive.

The conveyance of pot-ale through pipes, necessarily under considerable pressure, is a troublesome matter on account of leaking joints. It is easy to understand that warm acid pot-ale must have a corrosive action upon metal, while the expansion and contraction of the pipes, due to alternations of temperature in the liquid, must put a severe strain upon the flanges. Any leak in such a pipe means a serious overdose of pot-ale at that particular part of the field, whilst the putting of a leak to rights is costly; besides that, it disturbs the soil and subsoil.

The best method of distribution is from carts fitted with a rough spraying board. By this method pot-ale can be applied to grass land without risk of burning the grass, but specially favourable conditions as regards proximity of the land to the distillery and as regards gradients are essential, or the cost of carting becomes prohibitive. On steeper gradients distribution by means of canvas hose pipes, moved every hour or so, works well. On land with slight gradients, distribution by means of grips cut in the soil may be sufficient under good supervision, provided that the flow of pot-ale is gentle and its direction is altered once or twice a day.

The manurial value of pot ale is well illustrated by the great improvement in the pasture at the Glenlivet distillery, while similar improvement has been observed at other places in the yield of grass, oats and turnips.

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* Hendrick, *loc. cit.*

SECTION II.

Purification of Distillery Waste Liquors on Contact Beds.

In the great majority of cases, distilleries have been provided, during recent years, with more or less elaborate systems of contact beds for the disposal of waste liquors. A description of some of these installations is given in Section III. It was felt, however, that the results from those installations did not afford sufficiently accurate data with regard to the value of a contact bed system for the treatment of distillery waste liquors. The following experiment was therefore made, to elucidate the point, and to see how far the existing plants might become available in any future schemes.

Dr. Cowie, of Mortlach Distillery, Dufftown, kindly placed his contact bed system at the Commission's disposal

Mortlach Experiments.

1. The object of the first experiment was to determine the character of effluent produced by treating a 5 per cent. solution of pot-ale, after liming and settling, on a system of seven contact beds. For this the beds as they existed at the time were used. They were each about 27 feet by 23 feet and were filled to a depth of 2 feet 6 inches, with clinker and limestone chips. The upper three beds were of coarse clinker and limestone, from about 3 inches to 5 inches diameter, while the lower four beds were filled with a mixture of medium clinker and limestone in equal parts. In the bottom of each bed there were about 9 inches of very coarse limestone, for drainage purposes. The total contents of the seven beds amounted to 370 cube yards of filtering material.

Since the beds had been recently in use, it was unnecessary to mature them afresh. From 28th February to 15th March, 1907, two fillings per week of a 10 per cent. solution of pot-ale, limed and settled, were given. The final effluent, however, was not good, and on 15th March a limed liquor of half the strength, *i.e.*, containing 5 per cent. of pot-ale, was employed.

Two fillings a week continued to be given until 10th April. In practice the beds were filled to the top of the material, the liquid being roughly distributed by means of perforated iron sheets, and an hour's contact was given in each ; this was equivalent to ·45 gallon of pot-ale per cube yard of contact bed per filling. The number of fillings per week was increased to three, from 11th April to 30th June, 1907.

The effluent obtained was of rather poor quality and usually putrescent upon incubation. The average figures for "oxygen absorbed" from $\frac{N}{8}$ permanganate in four hours at 27° C (80° F.), for the limed liquor and effluent, respectively, between 23rd April and 30th June, were 50·0 and 4·0 parts per 100,000. The percentage purification calculated on this basis was, therefore, 92, showing that a very large amount of oxidisable matter was removed. The effluent contained practically no nitrate and always had a faint brewery smell. These figures are the average of six samples of limed liquor and eight samples of effluent. Detailed figures are given in Appendix V.

The aggregate purification effected per cube yard of filter was thus very small, and it was felt that, on theoretical grounds, based on the experience of the Commission with sewage, a much greater amount of purification should be obtainable from contact beds treating distillery waste liquors. It was, therefore, decided in the autumn of 1907 to alter the material composing the beds as follows :—

The 1st and 2nd beds were made 6 inches deeper, by the addition of coarse clinker similar to that already in them.

The 3rd, 4th, 5th and 6th were emptied and refilled with clinker which passed a one-inch screen, while their depth was increased to 3 feet. About 4 inches of coarse limestone were placed in the bottom of each of these four beds, for drainage purposes, but all other limestone was removed.

The last of the series of the seven beds was emptied and used as a storage tank for the effluent.

The effect of these modifications was that the six beds now held 380 cube yards of filtering material, of which two-thirds (*i.e.*, the material of the last four beds) was of fine grade.

2. The second experiment was commenced towards the end of November, 1907. As the beds were practically new, they were kept moist for the first fortnight with a weak solution of pot-ale, limed and settled. The number of fillings was then increased gradually to four per week, from 1st January, 1908. The liquor to be treated consisted of pot-ale one part, water nineteen parts, limed and settled. This rate of treatment was maintained until 27th April, 1908, during which period a moderately good effluent was obtained, seven samples of effluent out of thirteen drawn withstanding incubation. The average figures for "oxygen absorbed" from $\frac{N}{8}$ permanganate in four hours at 27° C. (80° F.), for the limed liquor and effluent, respectively, were 61·9 and 2·45 parts per 100,000. The percentage purification based on this test therefore amounted to 96, a result which justified the alteration of the beds, since an increased amount of pot-ale was treated per cube yard of filter, as compared with Experiment I., and by means of six contacts in place of seven. Again, the effluent contained practically no nitrate, and always had a faint brewery smell. Figures of analysis are given in Appendix V.

The quantity of pot-ale treated per cube yard of filter during this experiment was equivalent to ·33 gallon per day, six days a week, or ·5 gallon per cube yard of filter-bed per filling.

There is little doubt that the smallness of the volume which could be treated was largely due to the wintry weather, but in dealing with the question of the disposal of distillery waste liquors, it has to be borne in mind that the greatest demand on the purification plant of necessity occurs during the winter months. In practice it would not be possible to hold up the waste liquors over any prolonged period of severe frost.

It seemed from these two experiments that the series of six contact beds might reasonably be called upon, especially with the advent of milder weather, to treat a much larger volume of the limed liquor, though in all probability the final effluent would not be of very high quality. In order to settle this point, and to arrive at a better knowledge of the purifying power of the contact beds, a third experiment was commenced on 28th April, 1908.

3. The liquor treated again consisted of a 5 per cent. pot-ale solution, limed and settled, but the number of fillings was increased from four to six, nine, and finally twelve per week, the latter rate being attained on 18th May. From 18th May to 1st June the beds therefore received two fillings of this 5 per cent. liquor per day, six days a week. On 1st June the strength of the liquor was doubled, the beds continuing to receive twelve fillings per week. From 29th April to 16th May the average figures for "oxygen absorbed" from $\frac{N}{8}$ permanganate, for limed liquor and final effluent, were 53·3 and 5·64, the purification calculated on this basis being therefore 89 per cent. These are averages of six samples. From 16th May to 1st June the corresponding figures were 52·8 and 4·61, the percentage purification being 91. These figures are averages of four samples. From 1st June to 24th June the liquor treated consisted of a 10 per cent. solution of pot-ale, limed and settled. The respective figures for "oxygen absorbed" in this case were 75·0 and and 4·89, with a percentage purification amounting to 93·5. These are averages of 11 samples of limed liquor and 19 of effluent. Through the whole course of this experiment, *i.e.*, 28th April to 24th June, all the 29 samples of effluent tested were putrescent upon incubation. Nitrate was

only tested for in a few samples. Practically speaking, there was none present. The final effluent was only slightly opalescent and was entirely free from suspended solids. It had a faint brewery smell. During the month of June two gallons of pot ale per cube yard of filtering material per day were dealt with. At this point it may be convenient to give a short table which summarises the facts.

	23rd April to 30th June, 1907.	1st January to 28th April, 1908.	29th April to 15th May, 1908.	16th May to 1st June, 1908.	1st June to 24th June, 1908.
Number of successive contacts -	7	6	6	6	6
Number of fillings per week - -	3	4	Increased gradually to 9.	12	12*
Gallons of pot-ale, limed and settled, treated per cube yard of filter per day, six days a week -	·25	·33	·33 to ·75	1·0	2·0
Oxygen absorbed from $\frac{N}{8}$ permanganate in four hours at 27° C. (80° F.) in parts per 100,000—*Limed liquor* - -	50·0	61·9	53·3	52·8	75·0
Oxygen absorbed from $\frac{N}{8}$ permanganate in four hours at 27° C. (80° F.) in parts per 100,000—*Final effluent* - -	2·70	2·45	5·64	4·61	4·89
Percentage purification based on this "oxygen absorbed" figure -	95	96	89	91	93·5
Number of samples drawn—					
(*a*) Limed liquor - - - -	6	8	6	4	11
(*b*) Effluent - - - - -	8	13	6	4	19

At the end of these experiments the beds appeared to be in perfectly good condition. There were no growths on the surface nor was there any evidence of internal clogging.

4. *Treatment of limed steep water upon contact beds.*—During November and December, 1908, a strong steep water, limed and settled, was treated on the six contact beds at Mortlach, at the rate of 20 gallons of limed liquor (containing about 60 per cent. of steep water) per day. This limed liquor varied greatly in strength, its average figure for "oxygen absorbed" in 4 hours, as shown by five samples drawn over a period of six weeks, being 51·0 (25·7 to 84·5). The corresponding figure for the sixth contact effluent, which was putrescible on incubation, was 10·3; but it, too, varied greatly, viz., from 4·2 to 19·5. The purification effected, as calculated on the "oxygen absorbed from permanganate," averaged in this case 80 per cent. This effluent received its final purification upon land.

Channel Experiments with the Contact Bed Effluent.

Throughout the experiment, portions of the effluent from the final contact bed were allowed to flow along two wooden channels about 80 yards in length.

In one channel the effluent was diluted with about an equal volume of burn water, the other carried undiluted effluent. The channels were in all respects similar to those used at Coleburn.

Owing to the somewhat poor quality of the effluents obtained during the experiments, grey growths were always present in the channel carrying the undiluted effluent. The first 15 to 20 yards of the channels accounted for the bulk of the growths; beyond this they were usually mixed with green algae to about half-way along the channel. The lower half of the channel rarely showed any grey growths, and none were seen in the tank into which the channels discharged. The channel carrying the effluent, once diluted, usually showed grey growths in small amount, extending to 10 to 15 yards. In this case the grey growths were mingled with green algae, from the inlet end. The lower reaches down to the discharge tank showed green algae alone. Frequent examination of the River Dullan, at and below the point at which this discharge tank overflowed into it, revealed no change in the character of the vegetation occuring naturally. Further, there was no sign of frothing or other evidence of pollution. The dilution taking place here was of course very great.

Summary and Conclusions with regard to Contact Beds.

Owing to the comparatively short time which was available after the alteration of the beds, these experiments could not be carried out as they might have been, had the time allowed been longer, and they are not put forward as exhausting the subject. On the other hand, the following conclusions may be safely drawn from them :—

(I) Diluted pot-ale, limed and settled, is amenable to purification by means of contact beds.

(II) Neither six nor seven contacts are sufficient to produce a uniformly non-putrescible effluent, from either a 10 per cent. or a 5 per cent. solution of pot-ale, limed and settled. Probably eight contacts, in beds composed of fine material throughout, would give a non-putrescible effluent, treating a 10 per cent. pot-ale solution.

(III) As regards the quantity of pot-ale that can be treated, it is clear that a given quantity of material, arranged in the form of contact beds has considerably less purifying power than it would have were it in the form of a percolating filter. Based on the results of the experiments, it is possible that with eight contacts in beds of fine material, an average of 1·0 to 1·5 gallons of pot-ale could be dealt with effectively per cube yard per day. In very cold weather it would probably be inadvisable to attempt to deal with more than 1 gallon per cube yard per day.

In conclusion, it might be well to emphasize the point that, owing to the limited supply of oxygen to a contact bed, it is better suited to the treatment of a weak rather than a strong liquid.

At distilleries where contact beds exist, they would be best employed for the disposal of the waste liquors other than pot ale, though, as the above experiments have shown, diluted pot-ale can also be purified; but for a complete installation the contact bed system compares unfavourably, as regards efficiency, with percolating filtration.

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* Strength of limed liquor doubled.

SECTION III.

Treatment of "Continuous Flow" Steep Water upon a Percolating Filter.

There are two methods in general use for the steeping of barley. In one method the barley, having been placed in a tank, is subjected to two or three successive soakings of water. About eight to ten gallons of steep water per bushel of barley result. In the other method the water is allowed to percolate through the barley in a constant stream. This method results in the production of a much larger volume of steep water of a weaker character. No definite statement can be made as to the volume of steep water produced by this latter plan; it varies according to the condition of the barley, the amount of water available, and the individual ideas of the maltster. There is no actual difference between the two kinds of steep water except as regards strength.

At Coleburn, as will be seen on reference to page 22, it was shown that steep water which was produced by the former of these two methods was easily amenable to treatment on the percolating filter. In the experiment now under consideration it is seen that a continuous steep water can also be purified by the same means. The experiment was carried out at Mortlach Distillery in the early spring of 1907 and the winter of 1907–8, upon a filter kindly placed at the Commission's disposal by Dr. A. M. Cowie. The filter was circular, 12 feet 3 inches in diameter and 10 feet 6 inches deep. It was filled with rather coarse clinker, the pieces ranging from 1 to 3 inches in length, the bulk measuring from 2 to 3 inches. The clinker rested on a concrete floor and was held in position by a circular wall of open-work limestone. The total cubic content of the filter amounted to 45 cube yards. The filter was fitted with a small revolving distributor, which was fed automatically from a tipping box constructed to discharge five gallons of liquid at a time.

The steep water used throughout the experiment was first passed through a small tank containing a few lumps of lime, and then into a reservoir tank from which it was delivered to the filter. The settlement given in the reservoir tank varied greatly, but it was usually sufficient to remove the heavier suspended matter contained in the steep water. As a rule, a continuous flow steep water does not contain a great quantity of suspended matter, but a preliminary tank affords protection for the filter against grit and any large solid matter washed from the barley. The rough liming was no doubt useful to some extent in checking the tendency of the steep water to become acid, but it need not be regarded as a necessary adjunct to the process.

The steep water dealt with varied greatly from time to time, as will be readily understood when it is stated that the maximum and minimum figures for oxygen absorbed from permanganate in four hours at 27° C. were 72·8 and 13·6 per 100,000 respectively. The average analysis (nine samples) of the steep water as discharged on to the filter was as follows:—

Ammoniacal nitrogen - - - - - - - - -	0·14	parts per 100,000.
Albuminoid nitrogen - - - - - - - - - -	0·48	„ „ „
Oxygen absorbed from $\frac{N}{8}$ permanganate in four hours at 27° C. -	22·5	„ „ „

Taken as a whole, the settled steep water dealt with may be described as an almost clear, yellowish-brown liquid, with an "oxygen absorbed" figure equal to that of a very strong sewage, and as having a putrid smell. It frothed persistently on shaking.

In the season 1906–7 the filter was worked for a short time only, viz., five weeks. During the first four weeks of this period it received 500 gallons of steep water per day, working for ten out of twenty-four hours. During the last week 1,100 gallons were treated per twenty-four hours, working day and night. At the slower rate of working a clear non-putrescible effluent was obtained, while at the higher rate it became opalescent and putrefied on incubation. It must be added, however, that during this latter period very severe wintry weather was experienced.

The filter was re-started on 20th October, 1907, and worked continuously from that time until 22nd January, 1908, receiving steep water at the rate of twenty five gallons per cube yard per day throughout the whole of the twenty-four hours. The effluent obtained was uniformly good. It contained very few suspended solids, it did not froth on shaking, and all samples withstood incubation. The average analysis of the effluent during the second period of work was as follows:—

Ammoniacal nitrogen - - - - - - - - -	0·02	parts per 100,000.
Albuminoid nitrogen - - - - - - - - - -	0·12	„ „ „
Oxygen absorbed from $\frac{N}{8}$ permanganate in four hours at 27° C. -	1·64	„ „ „
Nitric nitrogen - - - - - - - - - - - -	trace	„ „ „
Suspended solids - - - - - - - - - - -	1 to 3	„ „ „

The suspended solids were blackish-brown in colour and consisted mainly of decayed vegetable matter with a little grit, washed out from the clinker, and a number of small worms and fly larvæ.

During the experiment *Fusoma parasiticum* flourished to such an extent on the surface of the filter that it was necessary, every four or five weeks, to remove the top few inches of clinker and replace it with clean material. At no time were there any indications of internal clogging.

The effluent produced in this experiment was allowed to flow along channels similar in every respect to those mentioned in relation to the contact bed experiment at Mortlach. One channel carried undiluted effluent and the other effluent and water in about equal proportions. Observations over a period of three months did not reveal the presence of white or grey fungoid growths in either channel.

Green algæ grew in both channels, but to a greater extent in the channel carrying the mixture of effluent and water. It should be observed that, in a control channel along which water alone flowed, there were abundant growths of similar algæ. Careful examination of that part of the River Dullan into which the effluent discharged did not indicate anything abnormal. There was no apparent difference in the nature or amount of the algæ about the outfall, nor was there any frothing.

It is clear from this experiment that a continuous flow steep water is amenable to treatment on a percolating filter, with the production of a good effluent. The experiment was not carried far enough to show the limits of the process, *i.e.*, the maximum quantity of steep water which could be purified per cube yard of filtering material. Owing to the excessive variations in the strength of the steep water, this point would be difficult to determine. It may be said, however, from experience with sewage, that probably from thirty to forty gallons of a similar steep water would be the maximum which could be treated, on the average, per cube yard per day.

On the basis of the experiment, a distillery steeping 1,000 bushels of barley per week, with, say, 24 gallons of water per bushel, would require a percolating filter of 160 cube yards content. On account of the rapid devolopment of growths on the surface, it would be best to construct the filter in the deep, rather than in the shallow form. When provision is made for the treatment of diluted pot-ale on a percolating filter, steep water can of course be used as one of the diluents. *Cf.* page 22, Coleburn experiments.

Purification of Diluted Pot-Ale on a Percolating Filter, without the previous addition of Lime.

The success which attended the treatment of diluted pot-ale at Coleburn, after liming and settling, led the Commission to think that diluted pot-ale alone, without the previous addition of lime, and possibly even crude pot-ale, might be amenable to biological purification. It has not been possible to attempt any experiments with undiluted pot-ale, but in the winter of 1906 an opportunity arose at Mortlach Distillery for experimenting upon the purification of diluted pot-ale, and in June, 1907, advantage was taken of this. The largest of Dr. Cowie's percolating filters was used for this experiment. It was 13 feet 9 inches in diameter and 13 feet 6 inches deep, the total cubic content being 74 cube yards.

The filter was composed of coarse clinker of about 2 inches in diameter, this resting on a concrete base and being held in position by an open-work limestone wall. The filter was fitted with a special revolving distributor, fed automatically from a small tipping box, which was set to discharge five gallons at a time. A circular wooden tank holding 1,800 gallons was constructed near the filter, for the purpose of diluting the pot-ale and giving the mixture settlement before filtration. The liquor used during the experiment consisted of pot-ale one part, water nine parts, the usual plan being to make up the mixture in the evening and to allow this to stand overnight. The experiment began on 7th February, and continued to 31st July, 1907, with the exception of five days in March, when the delivery pipes were frozen up.

The liquor treated, with the exception of one or two samples, was of fairly constant strength throughout the experiment. An average of thirteen samples gave on analysis the following figures:—

Ammoniacal nitrogen (1·20 to 1·90) - - - - - - - - - -	0·85	parts per 100,000.
Albuminoid nitrogen (5·10 to 10·10) - - - - - - - - -	8·25	„ „ „
"Oxygen absorbed" from $\frac{N}{8}$ permanganate in four hours 27°C. (89·60 to 190·40)	141·0	„ „ „

It was a ropy yellow-brown liquor, having a strong sour smell and producing a very persistent froth on shaking. It was invariably acid in reaction.

In contrasting the results obtained in the treatment of this liquor with those obtained at Coleburn, the great difference in strength must be kept in mind, and it must also be remembered that the effect of the precipitation by lime results in a purification amounting to about 15 per cent., as measured by the oxygen absorbed from permanganate in four hours at 27°C. The filter was worked for ten hours per day during the whole of the experiment. From 7th February to 27th May the rate of filtration was gradually increased. During February it amounted to one-tenth of a gallon of pot-ale, *i.e.*, one gallon of liquor per cube yard per day. From 1st March this dose was doubled, being again increased on 1st April to 0·5 gallon of pot-ale, *i.e.*, five gallons of liquor per cube yard per day. From 8th to 27th May, the rate of filtration was 0·8 gallon pot-ale per cube yard per day, while from 28th May until 31st July, when the experiment ended, the filter received ten to eleven gallons of liquor per cube yard per day, equivalent to 1 to 1·1 gallon of pot-ale.

As will be seen from the following table of analysis, the composition of the effluent varied considerably, this being due mainly to the exposed position of the delivery pipes, which froze up during severe weather, and to the clogging of the surface of the filter by growths.

Parts per 100,000.

Date.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Nitric Nitrogen.	Oxygen Absorbed from Permanganate in 4 hours at 27° C.	Incubation (by smell).	Rate of filtration of pot-ale per yard cube per day.
1907. February 12th - -	0·17	0·45	4·45	9·60	Failed.	0·1 gallon.
„ 28th - -	0·04	0.33	3·64	1·60	Passed.	0·1 „
March 12th - -	0·05	0·31	3·24	2·42	Passed.	0·2 „ (from 1st March).
April 11th - -	0·06	0·31	2·48	8·58	Failed.	0.5 gallon (from 1st April).
„ 23rd - -	0·04	0·23	1·08	1·56	Passed.	0·5 gallon.
„ 30th - -	0·02	0·45	1·24	6·24	Failed.	0·5 „
May 6th - -	0·04	0·22	1·68	2·02	Passed.	0·5 „
„ 14th - -	0·02	0·36	1·44	1·86	Passed.	0·8 „ (from 7th May).
„ 29th - -	0·12	0·57	0·33	5·30	Very stale.	1·0 gallon (from 27th May).
June 4th - -	0·10	0·25	0·52	4·90	„	1·0 gallon.
„ 13th - -	0·05	0·26	0·42	4·16	Failed.	1·0 „
„ 26th - -	0·06	0·21	0·45	4·08	Passed.	1·0 „
July 24th - -	0·02	0·22	2·43	1·36	Passed.	1·0 „

As a general rule the effluent was practically colourless and contained very little suspended matter. It had no smell and did not froth on shaking. It was invariably neutral to litmus paper. The result was thus a very striking one, especially in regard to the percentage purification, which averaged 97·2, as measured by the oxygen absorbed from permanganate in four hours at 27°C., and this, moreover, from an acid liquid.

The humus flora, *Fusoma parasiticum*, grew abundantly on the surface of the filter, and it was necessary to remove the top layer of clinker twice during the six months, namely in April and June. As regards quantity and rate of growth, no distinction can be made between this filter and the one at Coleburn.

The suspended solids in the effluent were also very similar, both in quantity and composition, to those issuing from the Coleburn filter. No signs of internal clogging of the filter presented themselves during the experiment.

As in the case of the other experiments at Mortlach, the effluent was allowed to flow along two channels, each about eighty yards in length, before reaching the River Dullan. One channel carried the effluent alone, and the other a mixture of effluent and water in about equal proportions. No grey or white growths were observed in either channel, but green algæ flourished abundantly, though not to a greater extent than they did in the control channel carrying water alone. It was noticeable that in the undiluted effluent channel, extending over the first twenty yards or so, *Rhizoclonium hieroglyphicum*, a dark green growth, was generally in evidence. This same growth constituted the bulk of the algæ found in the effluent channel at Coleburn.

The experiment shows that diluted pot-ale, without prior treatment by lime, is also amenable to biological purification. Though no accurate comparison is possible between this experiment with (merely) diluted pot-ale and the experiments at Coleburn with limed and diluted pot-ale, in practice it would probably be always best to use lime, on account of the better clarification obtained, and because the sludge produced is much less liable to cause nuisance on drying, besides being more easily handled for use as a manure.

SECTION IV.

A Description of the several Processes for the Disposal of Distillery Waste Liquids in use (1906–7) *at various Distilleries in the North of Scotland, with some remarks as to their Efficiency.*

Up to ten or twelve years ago, very little was done to purify distillery waste liquors. In some cases it was considered sufficient to discharge the whole of the waste liquids into pits formed by simple excavation near the distillery, while in others they were sent direct into the stream. At the time of the first visit of the Commission to the Speyside district, in May, 1903, purification plants of some kind had been erected at a number of distilleries. In one or two instances the pot-ale was being effectively distributed over land, but at the majority of places evaporation, incineration, or contact bed treatment, or a combination of these, was employed, with results that could not be called satisfactory. There were still some distilleries where the waste liquors were simply pumped into earth pits and allowed to soak away. Beyond this, classification of the processes is not possible. Except for the construction of experimental percolating filters at Mortlach Distillery, little development has taken place since that time. The description given below may be taken broadly as applying to the period 1906–7.

At all the distilleries facilities were given to neighbouring farmers to cart away pot-ale, for use as a manure or as a cattle food. Generally, the distillers themselves have a farm attached to the distillery, and some pot-ale is disposed of in this way. There is no doubt whatever that dressings of pot ale, judiciously applied, with an occasional dressing of lime, form an excellent manure for grass or oat crops. Local opinion is divided as to its value as a cattle food, but the results at Mortlach and Minmore seem to show that it is of considerable value when used for this purpose. On the other hand, it is said to cause rheumatism on account of its acidity.

It should be specially noted that the figures given for the quantities of barley malted per week, and consequently for the volumes of waste liquors produced, refer only to particular periods. They do not represent the maximum output of the distillery in any instance. The figures for cost can of course only be taken as very approximate.

Aberlour Distillery.

This distillery is situated in the village of Aberlour and on a small stream discharging into the river Spey, about three-quarters of a mile distant. The respective volumes of waste liquors produced are :—

Pot-ale, 24,000 gallons per week.
Steep waters, 20,000 gallons per week.
Wash waters and spent lees, together about 25,000 gallons.

Method of treatment.—The pot-ale is run hot from the still and pumped to a tank, in which it is again brought to the boiling point by means of a steam coil. Then about twenty-five pounds of lime of the best quality are added, per 3,000 gallons of pot-ale,—which is sufficient to render the liquid slightly alkaline. Whilst still boiling, sufficient superphosphate of lime is added to render the mixture slightly acid again, and the whole is boiled until the vigourous frothing subsides. The solid matter is now allowed to settle, which it quickly does, and the clear supernatant liquor is run off by means of a floating discharge to a cooling tank, where it is diluted with wash water and spent lees and pumped to a tank at the top of a system of contact beds. Here the liquid is rendered neutral by the addition of powdered lime and allowed to finally cool and settle. The clear liquid is then run into the first of a series of six contact beds, and two to three hours contact is given in each successive bed. The beds are filled with a mixture of clinker and limestone, together with a little magnesite, and each has a capacity of seventy cubic yards. The resulting effluent is stored in a tank and flushed into the stream at intervals.

The effluent, if judged by itself, is not satisfactory.

The sludge from the boiling and precipitation tanks amounts to about one ton per week. It is carted to a lagoon and allowed to dry in the air. It is not easy to sell, and the manager does not set any value on it at present. The proprietors hope to be successful, later on, in drying the sludge and disposing of it as a manure. The plant works 106 hours per week to deal with the weekly production of pot-ale.

The *Steep Water* is separately treated. It is collected, limed and settled, and allowed to strain through two small filters filled with sand and gravel to a depth of one foot. The effluent, which is a poor one, flows into the burn of Aberlour.

The *Cost* of the whole plant, which had been working for four years, amounted to £2,500, but in addition to this, over £1,000 had been spent in experimental works. The annual cost was £600, and the amount of barley malted 2,000 bushels per week.

Coleburn Distillery.

This distillery is situated about six miles from Elgin in the Rothes Valley, and on a small stream known as the Cole burn. During the season 1905–6 the volume of waste liquors produced was :—

Pot-ale 8,000 gallons per week.
Steep water 8,000 gallons per week.
Wash water and spent lees 10,000 gallons per week.

Process.—The liquors are all mixed and pumped to a settling tank at the top of a series of six contact beds. Here the liquor is limed and settled and diluted with about an equal volume of water. It is then run into the beds successively, giving two hours contact in each bed. The beds are filled to a depth of three feet with boiler furnace clinker and each contains approximately seventy cube yards. Only a partial purification is effected, and the effluent at this stage is a turbid and foul smelling liquid. It is run into tanks and then pumped away over a large tract of grass land on the top of a neighbouring hill, some 300 feet higher up. Here it is distributed by means of canvas hose pipes, which are moved daily, the result being that it disappears altogether. Careful examination of the ditches on the land, extending over a year, has never revealed the presence of grey growths. The sludge from the settling tanks is mixed with road scrapings, soil, etc., and carted to the land and used as manure.

The initial cost of the plant and beds amounted to £600. The annual cost of maintenance is approximately £180. The amount of barley mashed was 600 bushels per week.

Here we have an instance of partial purification of waste liquors, followed by land treatment, the result being a perfectly satisfactory disposal. The proprietors of the distillery are fortunate in having a large area of suitable land which they can use as they like.

The material used in the beds is of rather a soft nature and liable to disintegrate. For this reason, and owing to the rapid clogging of the beds, it has been found necessary to remove the material once a year. On these occasions, which of course occur in the summer, the clinker has been washed, riddled and replaced, any deficiency being made up with fresh clinker.

The dose of liquids applied to the beds is altogether out of proportion to their purifying capacity, but in this instance only a partial purification is aimed at.

Glen Elgin Distillery.

This distillery is situated on the Cole burn, about one and a half miles below Coleburn Distillery and the same distance above Longmorn Distillery. When the Commission's work at Coleburn began, the Glen Elgin Distillery was closed, but in 1907 it was again brought into use. The waste products comprised 8,000 gallons of pot-ale, 8,000 gallons of steep water and about 10,000 gallons of wash water and spent lees per week. The treatment of these liquids consisted in simply pumping them into a large gravel pit, on rising ground close to the stream. The sub-soil in the vicinity of the distillery is chiefly sand and gravel, and it is not surprising, therefore, that shortly after the distillery operations began, sewage fungus appeared and flourished in the burn and in the mill-lade and dam below the distillery. Previous to this there were no signs of pollution between Coleburn and Longmorn.

No figures are available with regard to the cost of this method of disposal as used at Glen Elgin.

Convalmore Distillery.

This distillery is situated in the Dufftown district, on high ground sloping away to the River Fiddich, about a quarter of a mile distant. The Manager stated that the waste liquors amounted to :—

16,000 gallons of pot-ale per week.
10,000 gallons of steep water and all other liquids per week.

The pot-ale is disposed of by means of a Lennox evaporator. In this process the waste heat of the boiler furnace, supplemented by an auxiliary furnace, is led into chambers into which the pot-ale is sprayed in fine jets. These chambers are situated at the foot of the chimney, up which the products of combustion pass. Such pot-ale as is not consumed in the first instance is returned to the chambers, and the resulting product is a more or less sticky mass, which is scraped out of the bottom of the chambers at the end of the week's work. About two tons per week of this material is produced, and it can be sold at 22s. 6d. a ton, for use as manure.

The capital cost of the plant was £1,200, and it entails an annual charge of £225 for maintenance.

The amount of barley mashed was 1,200 bushels per week.

The steep water is kept separate and run into a large hole in the ground near by. As the sub-soil is chiefly gravel, the liquid drains away obviously in the direction of the river.

The other liquids are run into natural earth tanks constructed by simple excavation and banking. There are four of these tanks. The liquid slowly soaks away into the ground, some of it doubtless finding its way into the River Fiddich in a more or less purified condition.

Here we have an instance of the practical destruction of the pot-ale by heat. The process is economical in that it makes use of the otherwise waste heat of the boiler furnace. On the other hand, the product of the torrefaction is not of much value as a manure, and is in a very unsuitable condition for applying to land. Complaint is justly made of the smoke emitted from the chimney as the result of this process, and especially because of the very objectionable smell imparted to it. This smell is not easy to describe. At the very beginning of the week it is not unpleasant, but it rapidly becomes an acrid and penetrating odour of a most objectionable character, and can frequently be detected two or three miles away. Such a smell was referred to in the evidence given by the riparian owners to the Commission, when it was described as "polluting the air."

As regards the other liquids, it only remains to be noted that in the ponds holding them sewage fungus flourished, and that in the ditches on the land below them and leading to the river grey growths have been frequently observed, as also occasionally in the river itself, just where the land drain enters. The pollution thus caused cannot be regarded as serious, but it is additional evidence that the waste liquids, other than pot-ale, should be included in a purification scheme.

Glengarioch Distillery.

This distillery is situated in Old Meldrum on a very small burn, and is about five miles from Inverurie, Aberdeenshire. The distillery was visited at the request of Oxychlorides, Ltd., as their process was employed there. The distillery produces about 14,000 gallons of pot-ale per week, which, together with about an equal volume of wash waters, is treated by the "Oxychloride" process. "Oxychloride" is an alkaline solution of hypochlorite of sodium, made by electrolysing a salt solution until it has "available chlorine" equivalent to 0·2 per cent. Sodium carbonate is then added to the electrolysed salt solution and the liquor is stored. It will keep in this condition for a week, at least. In the process, 10 gallons of this liquor are added to 100 gallons of the mixture of pot-ale and wash water in equal parts. A copious precipitation occurs and the precipitate is allowed six to seven hours for settlement. The precipitate, consisting largely of proteid and carbo-hydrate matter, is used as a pig food with considerable success. The clear liquid is run off and rendered alkaline with lime, the resulting phosphate of lime being settled out and added to the manure heap. The clear liquor is then diluted with about an equal volume of water and passed by upward continuous filtration through two small filters, 6 ft. by 4 ft. by 3 ft. 6 in. deep, the first of which is composed of small gravel and the second of fine cinders. The effluent is collected in a large tank and sent down the burn in flushes. In appearance the effluent was fairly bright and had a saline taste; on shaking, it frothed very persistently. It is discharged into a very small burn. At the time of my visit this was clean above the distillery, while for more than a mile below, the stones and the sides were covered with slimy grey and white growths and sewage fungus in abundance. The Oxychloride firm claim that much better could be done by their process, but as the distillery proprietors have no complaints brought to them, they consider it unnecessary to do more.

The capital outlay on the plant amounted to £700, and an annual charge of £210 is incurred for working and maintenance. The amount of barley mashed was 1,000 bushels per week.

The steep water and spent lees from this distillery are run straight into the burn, without treatment of any kind.

Ben Rinnes Distillery.

This distillery is situated in the Glen of Rinnes at the foot of the well-known mountain of that name. There is a small burn running past the distillery which eventually enters the River Spey at Aberlour. The waste products amounted to :—

24,000 gallons of pot-ale per week.

No accurate figures are available for the quantities of the other liquids, as the barley is steeped in running water.

The pot-ale is disposed of as follows :—

About 9,000 gallons per week are carted away and distributed over land in the vicinity of the distillery. The remaining 15,000 gallons are destroyed in a somewhat novel way. There are two chimney stacks for the distillery, and in the flue from the boiler furnace connected with each is placed a stout coil of copper piping. The pot-ale is forced into this coil at a pressure of 50 to 60 lbs. to the square inch and heated to the temperature of the flue, probably about 400° F. From the end of the coil the pot-ale emerges in a fine state of division at the bottom of the chimney, and it gets more or less dried up in its passage upwards. A considerable amount of it remains as a sticky mass on the inside of the chimney walls; but as a rule the chimneys take fire and burn out once a week and so clean themselves. Such unconsumed pot-ale as drains from the chimney is returned and passed through the coils again. There is generally a cloud of steam issuing from the chimneys, and the efficiency of the plant depends a good deal on the atmospheric conditions prevailing—dry, bright weather being the most favourable. The Manager reports that no apparent damage is done to the chimneys. The process had been working for six years.

Nearly £4,000 has been spent by the proprietors, principally in experiments dealing with the disposal of their waste liquids, but the actual cost of the destructor, as now used, was about £400. The depreciation and repairs naturally amount to a large percentage in such a plant, and a sum of £200 per annum is expended in upkeep and in working it.

The steep waters and other liquids.—The suspended solids in these are first well settled out. The liquid is then diluted four or five times with water and allowed to pass through three continuous filter beds in succession. The first has a content of 160 cube yards and is filled with fine cinders; the second and third are each 80 cube yards and are filled with fine gravel. The beds are arranged in duplicate, and work and rest alternately for a fortnight. The depth of material in them is 2 feet 6 inches. Great care is taken in the working of these filter beds and the resulting effluent is a good one. It was discharged into the small stream, above referred to, and did not produce any objectionable growth in it.

The total annual cost of the process, including the upkeep of the destructor and filter beds, as well as cost of cartage, amounted to £400. The amount of barley mashed was 1,600 bushels a week.

In this process we have an instance of the total destruction of the greater part of the pot ale, no attempt being made to recover any material of manurial value. The process is only possible for a distillery in an isolated position, such as that which Ben Rinnes distillery occupies, on account of the smoke and smell produced by the weekly combustion of the accumulated organic matter in the chimneys.

Parkmore Distillery.

This distillery is situated in the Dufftown district and on the River Fiddich.

12,500 Gallons of pot-ale are produced per week.

There is no record of the volume of the other liquors.

The pot-ale is run from a storage tank into a Multiple evaporator consisting of three units. Under a reduced pressure it is here evaporated to a thick syrup, in a manner similar to that described under the Rothes Purification Works.

The distillate from the evaporators is collected in a tank, where it is diluted and cooled before being run off into the River Fiddich. Some of the syrup produced is disposed of to farmers, for use as a cattle food, and realises twenty-five shillings per ton. The remainder is sprayed on to the slack used under the boilers and is thus eventually consumed. It is stated that a considerable saving of fuel is effected in this way.

The "other liquids" are mixed and settled, and run into a series of six contact beds, from three quarters of an hour to two hours contact being given in each bed. Three filtering materials are used—the first two beds being filled with clinker, the next three with small cinders, and the last with sand.

The effluent from this last bed runs into a dam, where it is diluted, and from which the mixture overflows into the river. Small quantities of grey growths were observed round the sides of the dam.

The cost of the whole disposal works amounted to £4,000, of which the contact beds cost £600. The Manager estimates that, excluding interest on capital and depreciation, it costs £350 a year to work and maintain the plant.

The amount of barley mashed was 900 bushels per week.

This is an instance of the evaporation of pot-ale to a syrup, with the idea of using it as a cattle food. Apparently there is not enough demand for the syrup, to allow of the whole of it to be sold. That the distillate from the evaporators is sometimes slightly contaminated with pot-ale syrup is to be inferred from the fact that traces of sewage fungus were observed in the bottom of the river, just below the distillery, especially when the river was small,

Dailuaine Distillery.

This distillery is situated about a mile from Carron Station, Great North of Scotland Railway, and on a small stream running into the Spey, half a mile distant. It is one of the largest distilleries in the north, producing from 40,000 to 50,000 gallons of pot-ale per week and proportionately large amounts of steep waters and other liquids; for the volumes of the latter, however, there are no available figures.

The pot-ale is disposed of in several ways at this distillery. Generally speaking, 9,000 to 10,000 gallons per week are carted away and used by farmers for cattle food, etc. During the spring of the year the pot-ale was disposed of by spreading over land. It was first pumped into a tank situated at the highest point of the land, from which it was conducted to various stand pipes at different positions on the area. It was discharged by means of a 2-inch canvas hose, connected to one of the stand pipes. Such a method of distribution would be a good one, if the pot-ale issuing from the hose were sprayed by hand over a suitable area. During 1906–7, however, the hose was left to run at particular spots for some time, the result being that part of the land received too much pot-ale, and part was left unused. The available area of land at this time amounted to about twenty acres and the greater part was very hilly. The soil is of a clayey nature and not well adapted for the purpose. During one period of ten weeks the whole of the pot-ale produced was distributed, as above, over twelve acres. This amounted to 3,000 gallons of pot-ale per acre per week. At another time 7,500 gallons per acre per week were distributed on a field of 6·5 acres for fourteen weeks in succession. These amounts are far in excess of what land of the best quality could satisfactorily treat.

The distillery is also provided with an installation of the Hunter process, already described when dealing with Aberlour distillery. Briefly, the process consists in boiling the pot-ale, rendering it alkaline with lime, then making it acid again with superphosphate, again neutralising with lime and allowing the precipitate to settle. In the case of Dailuaine, however, the precipitate was filter-pressed and dried, and used as a manure on the farm or sold as such. The clear supernatant liquor was evaporated by the Lennox process, as described under Convalmore. Sometimes the pot-ale was evaporated by the Lennox system, without previous treatment with lime and superphosphate. When the Hunter process and evaporator were used, about four tons of manure were produced per week, which when ground to a fine powder, was said to be worth about £3 per ton.

The steep water is disposed of by filtration through a double series of contact beds filled with clinker, and situated close to the River Spey. No analyses of the effluent have been made for the Commission. The Manager stated that no complaints had been made on the score of pollution by the effluent from these beds. It flows directly into the River Spey and the dilution taking place at this point is enormous.

The capital outlay in connection with the whole of the disposal plants, mentioned above, amounted to approximately £6,000. The annual expenditure was £1,460.

An average of 3,000 bashels of barley were malted per week.

Considering the large capital outlay, as well as the heavy annual cost, the results obtained at Dailuaine are disappointing. They serve to show to what little purpose money has been expended by distillers in the attempt to purify their waste products. No doubt the land available could be made to take a portion of the pot-ale, but how much, it is difficult to say. Probably 500 gallons per acre per week would be about the limit, provided that the distribution was very good.

In order to lessen the heavy annual expenditure, the proprietors of the distillery have recently (1908) obtained permission to dispose of their pot-ale on a neighbouring farm. Here a large area of fairly suitable land is available. Pipes have been laid in the ground and a pumping plant installed, by means of which the pot ale can be pumped to a large tank which commands the whole farm. The initial expenditure amounted to £1,000 and the total annual cost, including interest on capital, depreciation (at 10 per cent.), rent, wages and pumping, is estimated at £335. This is equivalent to the following charges per gallon of whisky :—

On an output of 250,000 gallons of whisky - -	0·32 pence.
" " 300,000 " " - -	0·27 "
" " 350,000 " " - -	0·23 "

The farmer is paid £60 a year for the use of his land, but the distillery company is liable to a week's notice from the superior landlord to discontinue, in the event of their operations causing pollution in the neighbouring stream. By bringing into use this further area of land, the disposal of the waste products has been much improved.

Those figures refer to the disposal of pot-ale only, the other liquids not being included. They are also based on the assumption that the area of land available is sufficient to continue to purify a very large volume of pot ale for a period of ten years.

Tamdhu Distillery.

This distillery is situated close to the River Spey, near Knockando station, Great North of Scotland Railway.

The waste products amount to 21,000 gallons of pot ale and 25,000 gallons of steep water and other liquids per week.

The pot-ale is evaporated in a multiple effect evaporator under reduced pressure and by the aid of steam, in the same manner as at the combined purification works at Rothes. The resulting syrup is charred in drying ovens, and the black solid residue after pulverisation is put on the market as a manure.

The other liquids, after dilution, are pumped to a large pond on some waste ground not far from the distillery. The subsoil here is a sandy gravel, and the liquids slowly disappear. The river, which is some 200 yards away, is of large volume at this point, and so far as could be observed no pollution was taking place.

The proprietors have spent some £3,500 in experiments dealing with the disposal of waste liquors. The actual cost of the present plant, which is not included in the foregoing sum, was £2,500. The Manager stated that the weekly cost of working the plant, including 5 per cent. depreciation on £2,500 capital, amounted to £16 10s. 0d. As a set off against this, two-and-a-half tons of manure were produced per week, which sold at £5 per ton, so that the actual net cost of the plant was £4 a week or £160 in an average year.

The plant had been working seven years, and so far few repairs had been necessary.

The same remarks apply to this evaporation and incineration process as to the Rothes plant which is described later, but as regards the burn at Tamdu into which the diluted distillate flows, it should be stated that on no occasion was the presence of grey growths observed.

Knockando Distillery.

This distillery is situated on the River Spey and close to Knockando station, Great North of Scotland Railway.

The waste products amounted to 17,000 gallons of pot-ale and about 80,000 gallons of other liquids per week.

Of the pot-ale, a little was carted away by farmers for use on land or for cattle, and the remainder was destroyed by the process of torrefaction of the Liquid Destructor Co., Ltd. In this process the waste heat from the boiler furnace, supplemented by an auxiliary furnace, is made to pass over trays placed in flues at the foot of the chimney. Into these trays pot-ale is run continuously, at such a speed as to equalise its consumption by the heat. The result is that the pot-ale is evaporated to dryness and the residue more or less charred to ashes, which remain in the bottom of the chimney ; the products of the evaporation and incineration pass up the chimney, producing the usual smoke and smell which accompanies such an operation. From 16,000 to 17,000 gallons of pot-ale yielded about 12 cwt. of dry ashes, which were used in the preparation of an artificial manure and were the property of the inventors of the process.

The steep water, wash water and spent lees, together with the domestic sewage from six cottages, were collected and allowed to settle, then diluted with an equal volume of water and treated on a system of contact beds, seven in number, each 20 feet by 30 feet by 1 foot 6 inches deep. The first was filled with limestone, the next five with cinders, and the last with gravel. About one-and-a half-hours contact was given in each bed. The resulting effluent ran into a ditch and thence into the River Spey.

The capital cost of the destructor plant and the contact beds amounted to £3,000. The total cost of working and maintaining the destructor amounted to £520 per annum, and the contact beds £150 per annum.

The amount of barley mashed was 1,200 bushels per week. In this case there was complete destruction of the pot-ale, but at a very considerable expense, and in 1907–8, in order to diminish expenses, the destructor process was not used, as the proprietors were, in that year, able to enter into a contract with a neighbouring farmer to cart away all the pot-ale produced and distribute it upon land. I understand that the sum paid for this cartage was £5 per week.

Mortlach Distillery.

This distillery, a large one, is situated in the Dufftown district, on the Dullan, just above its junction with the River Fiddich. The waste liquors produced amounted to 28,000 gallons of pot-ale, a "continuous flow" weak steep water of which no accurate figure of volume can be given, and about 30,000 gallons of wash waters, etc., per week. Just previous to the Commission's investigation, the pot-ale, together with all the other liquids, excepting the steep water, was settled and pumped to a series of eight contact beds, filled with clinker and limestone. and having a total capacity of 370 cube yards. Here, after dilution with twice its volume of water, the liquor was passed through the beds, two hours contact being given in each. The process did not give a satisfactory effluent. At this time a farmer, close to the distillery, offered facilities for the disposal of the pot-ale on his land for at least two years, and thus an instance of land treatment has been under observation from its inception. The land available amounted to about thirty acres at the time. It is situated on high ground, some 300 feet above the river. The soil is of a poor and clayey nature, averaging less than 12 inches deep, overlying a stratum of hard rock. The land slopes more or less steeply towards a little burn a mile distant, which joins the River Fiddich. There are a number of natural springs in the land hereabouts, which necessitates particular care in distribution of the waste liquors. The ale is pumped to a tank on the highest part and allowed to gravitate in roughly constructed grips over the land, and care is taken to distribute it as evenly as such a method admits. During the period of observation, season 1906–7, when almost weekly visits were made, some 900,000 gallons of pot-ale with the addition of wash waters and spent lees, were distributed in some forty weeks over ten acres, that is, 2,200 gallons of pot-ale per acre per week. This is a large dose per acre, but the land was fresh, and so far no sign of pollution was observed in any of the ditches and drains in the vicinity. In the beginning a small spring near the surface of the ground was contaminated, but directly this was observed the distribution was discontinued in that area.

The following are the figures of analysis given by a sample of the drainage water from the land receiving pot-ale, alongside of figures relating to a sample of water drawn from a pipe draining some neighbouring land, which had received no pot ale. Dry weather had prevailed for a month previous to taking the samples.

	Parts per 100,000.	
	Land Effluent.	Surface Water.
Ammoniacal nitrogen	0·002	0·007
Albuminoid nitrogen	0·0135	0·018
Nitric nitrogen	0·252	0·232
Oxygen absorbed from Permanganate* at 27° C. in 4 hours	0·107	0·195
Chlorine	2·00	2·20

In this case we have an example of land treatment under much less favourable conditions than prevail at Glenlivet. The soil is not so suitable, there was not so much land available, and the slopes are not so convenient. Still, so far, with care in distribution, the pot-ale has been disposed of to the great advantage of the farmer as regards his crops, and without causing pollution in the neighbouring streams.

The other twenty acres were brought into use in the season 1907–8, during which time very frequent examinations of the land and ditches were made. Again no evidences of pollution were observed. Since that time an additional area has also been acquired.

The cost of putting in pipes and tanks, for conveying the pot-ale to the land in the first case, amounted to £120. To this must be added £50 as an annual charge for supervision and maintenance.

The steep water produced (a weak one) was rendered neutral with lime and settled, after which it was roughly sprayed on to a circular percolating filter composed of clinker and limestone. The filter was 14 feet deep and contained between 80 and 90 cube yards of material. The resulting effluent was bright and clear, and there was no evidence of pollution in the stream at the point of discharge.

The costs shown above in no way represent the sum expended by Dr. Cowie in his attempts to deal with distillery waste liquors. A sum exceeding £2,000 has been spent in his pioneering experiments upon biological filtration.

Glenlivet Distillery.

This distillery is situated on the Livet, a tributary of the Spey, about six miles from Ballindalloch station, Great North of Scotland Railway. The waste products amount to 26,000 gallons of pot-ale and 100,000 gallons of other liquids per week.

Colonel Smith Grant, the proprietor of the distillery, is also tenant of the farm of Minmore, on which the distillery is situated, and a neighbouring farm 1½ miles away. On both of these farms cattle-raising is an important feature, and about 11,000 gallons of pot-ale per week are used as a part of the food and drink for the stock. Tubs and troughs are placed in the fields and byres and kept filled with pot-ale, the cattle consuming as much as they like, and to all appearance they thrive on it. The remaining 15,000 gallons are carefully distributed over the land in the neighbourhood of the distillery.

The other liquids are run to one or or other of two large settling ponds, made in the natural sandy gravel haugh, close to the River Livet. These ponds receive large amounts of surface water as well, and the liquids, well diluted, percolate through the gravel and disappear.

The method of land treatment applied to the pot-ale has now been in operation for ten years, and there is no doubt that the soil has benefited very greatly by it.

The soil is a poor one, and, previous to the use of the pot-ale as a dressing, the farm was the most backward in the district and produced meagre crops. But since the use of pot-ale the crops have greatly improved, and instead of being the most backward farm round about, it is now the most forward, producing good crops and especially good pasture, and enabling the proprietor to keep half as many cattle again per acre of pasture as the neighbouring farmers. The ground receiving the pot-ale does not show any signs of souring, and during the time the process has been under observation no grey growths have appeared in any ditch or drain, or in the River Livet.

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* The weak permanganate, generally used in water analysis.

There can be little doubt that this result is largely due to the care taken in distributing the pot-ale over the ground. It is all carried by carts and spread evenly over the land, and there is no overdosing of any particular part. Much, too, must depend on the fact that there is a large area, 300 acres, of most conveniently sloping ground close to the distillery and entirely at the proprietor's disposal, and which is remarkably free from springs. Before the ale is carted to the land, the suspended solids in it are first settled out in a large tank. It was found that these solids—chiefly the burst yeast cells—killed the young grass shoots, turning them brown, and thus spoilt the pasture. No precise figures can be given as to the amount of pot-ale that can be spread over any particular area, so much depending on the weather, rotation of crops, and other matters affecting the routine of a farm. However, one particular grass field of about 20 acres had received from 15,000 to 20,000 gallons of pot-ale per week for five weeks in succession. At the end of this time a sample of effluent issuing from the main drain of the field showed on analysis a water only a little inferior to a sample of the district surface water uncontaminated with distillery refuse.

The following were the figures of analysis obtained :—

	Parts per 100,000.
Ammoniacal Nitrogen	0·012
Albuminoid Nitrogen	·0623
Nitric Nitrogen	0·032
Oxygen absorbed from permanganate at 27° C. in four hours	0·292
Chlorine	2·10

With regard to the disposal of the other liquids, the settling ponds are very close to the river bank, and it may probably be taken for granted that some more or less unpurified liquor finds its way into the river. On the other hand, no evidence of pollution has been observed at any visit.

As regards the cost of this process, it is difficult to give any figures. On the one hand, the cost of carting amounts to about £300 per annum; on the other hand, there is permanent improvement of the soil and enhanced value of the crops. If a rent were paid for the land, it would be difficult to apportion a sum for disposal purposes. Again, saving in cattle food, both from the consumption of pot-ale and from the fact that Colonel Grant can pasture more cattle per acre than his neighbours, renders the estimation of cost still more complex.

In any case, the method of disposal adopted at this distillery is a striking tribute to the efficiency of land treatment, properly carried out on a suitable area of land.

Longmorn Distillery.

This distillery is situated close to the Longmorn Station, Great North of Scotland Railway, and on the Cole burn. Pot-ale to the amount of 14,000 gallons per week was produced. The steep water, of which there is no recorded volume, was run straight into the Cole burn. "Continuous flow" steeping is adopted. Wash waters and spent lees were run into a large sump. About one-third of the pot-ale was destroyed by the waste heat from the boiler furnace, by allowing it to trickle over a series of trays, so placed in the flues that the hot air and products of combustion pass over them in their passage to the chimney. About four to five cwts. of "ash" from the pot-ale were produced per week, and sold to artificial manure makers for about £3 per ton. Of the remaining pot-ale, some was carted away by farmers, and some was run into the sump or pumped away to a sand hillock, near by, where it disappeared. With the exception of that portion of the pot-ale which is destroyed by the waste heat, the plant is not satisfactory. The capital invested in the plant, which disposes of a portion only of the pot-ale, is £500, and a net charge of £75 per annum is necessary for its upkeep. The distillery is interesting by reason of the application of waste heat alone to dispose of a portion of the pot-ale. The destruction of even so small an amount of pot-ale gives rise to complaint on the score of smell and smoke, and in hot weather the stench from the sump is very bad, so that it becomes necessary to take advantage of a spate to clean it out and send the contents down the burn.

Glen Lossie Distillery.

This distillery is situated three and a half miles to the south of Elgin and about a mile from the River Lossie. On the eastward side of the distillery there is a small stream known as the Foths burn, which joins the Cole burn a couple of miles further on. The distillery is a large one and the waste products amount to 26,000 gallons of pot-ale and 100,000 gallons of steep waters and other liquids per week. The liquids, kept separate, are run into large tanks and allowed to settle. These tanks have natural bottoms, consequently there is always some leakage from them. From the tanks the clear liquid is pumped to a small tract of rough moorland—from two to three acres in area—and is allowed to run over it in rough channels cut in the ground and thus to percolate away. This land drains naturally towards the River Lossie. Since this method of treatment had been in use for eleven years, it was not surprising to find the small area upon which the liquids were run thoroughly soured and capable of effecting only a little purification. The effluent runs into an open ditch and finally into the River Lossie. The ditch nearly always had quantities of grey growths in it, and frequently these were observed over a distance of a hundred yards or more, in the Lossie itself, especially when the river was low. In the winter and spring, however, the river is generally a rapidly flowing one and of fairly large volume, and the evidences of pollution in it are not very marked.

The continual leakage from the bottoms of the tanks into which the liquids are first run occasions very gross pollution in a small burn running through the distillery land, and in the Foths burn, which it joins. There were always large quantities of grey fungoid growths when the distillery was working.

At the end of each distilling season the tanks are all emptied and the solids which have settled out are mixed with earth, road scrapings, etc., and carted to the land as manure. This distillery provides an example of a method of over-treatment on unsuitable land. In 1905-6, very little purification at all was being effected. During the summer of 1906 the area receiving the waste liquors was ploughed up and given a dressing of five tons of lime. This effected a little improvement in the purification during 1907, the Manager saying that he "had not had half as much trouble with the effluent as previously." Still, the ditch and drains and river all contained grey growth though not in such large amounts as in the preceding season.

The capital cost of the plant amounted to £700, and an annual charge of £60 is required for maintenance, etc.

Auchtertool Distillery.

This distillery is situated on a small burn about five miles from Kirkcaldy, Fifeshire. The process adopted here was examined chiefly because the system employed was the treatment on contact beds of the total waste liquors, and because it was said to give entire satisfaction to the riparian proprietors.

The process consists in mixing equal volumes of the pot-ale and other liquids (2,000 gallons of each is the daily out-put), adding excess of lime and allowing to settle twenty-four hours. The clear liquor is then run into a series of contact beds, seven in number, filled with fairly hard furnace clinker. The upper four beds have material from 1 inch to 3 inches in diameter, the lower three are filled with material of about ¾ inch to 1 inch. Before the liquor is passed into the first bed, it is filtered through a layer of about 4 inches of moss litter, in order to remove any suspended solids still remaining in it. The moss litter is removed from time to time as it becomes choked up, and sold as manure. One and a half hour's contact is given in each bed and the whole day's effluent is collected in a tank. At the end of each day's work the effluent, amounting to about 4,000 gallons, is diluted with 20,000 gallons of water and flushed into the burn. The work is carried out with great precision. The contact beds contain 800 cube yards of filtering material, and the day's work is therefore equivalent to 2·5 gallons of pot-ale per cube yard of bed per day (*cf.* Coleburn plant).

A very considerable purification is effected in this process. A sample of effluent taken during the visit gave the following figures on analysis :—

	Parts per 100,000.
Ammoniacal nitrogen	·08
Albuminoid nitrogen	·67
Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C. in four hours	16·0
Nitrous and nitric nitrogen	·032
Alkalinity as CaO	29·4

There was still a large amount of oxidisable organic matter remaining in the effluent, and one was not surprised to see a small quantity of grey growth on the sides of the tank containing it. However, the large dilution prior to discharging the liquid into the burn seems to have provided sufficient dissolved oxygen to purify this, and no fungoid growths could be seen in the burn itself.

Glenfiddich, Balvenie and Dufftown Distilleries.

These three distilleries are situated in the Dufftown district and are small ones. They provide examples of the old method of disposal of waste liquors which was required by the Public Health Act, Scotland, 1867, Section 83, which enacts that a distiller shall dig pits in or near his distillery, into which the waste liquors shall be run and allowed to percolate away.

Experience has shown that such a treatment sooner or later causes pollution of any stream in the vicinity.

With regard to the Glenfiddich and Balvenie distilleries, which are situated about half a mile from the River Fiddich, the treatment applied to the waste liquors was sufficient, in that no serious pollution of the river was caused. In examining the river from time to time, traces of fungoid growths were occasionally found close to places where drains from the land round the distilleries discharged into it.

The Dufftown distillery is situated on the Dullan, a stream which enters the Fiddich three-quarters of a mile below. Here the waste liquors are pumped into a pond 80 to 100 feet above the distillery, on land which on one side slopes away from the river, but on the other is bounded by a steep cliff forming one side of the valley through which the Dullan runs.

Small amounts of grey fungoid growths have been observed in little streams trickling down the cliff-side, but no real harm has so far been occasioned in the river itself.

Rothes Purifiation Works.

These works are situated close to Rothes station, Great North of Scotland Railway, and about one and a half miles from the River Spey. The works have been erected jointly by the proprietors of four distilleries in Rothes, viz., Glen Grant, Glen Spey, Spey-burn and Glen Rothes, in order to deal with the pot-ale produced between them. Previous to 1906, the whole of the waste liquors of these distilleries was taken into the town of Rothes sewers and treated at the Burgh Council's sewage works, which are situated close to the River Spey. The treatment adopted at the sewage works was precipitation with lime and alumino-ferric, followed by upward filtration through a very small filter, the effluent from which was finally passed over a small area of land. The effluent discharged from the works was exceedingly impure.

The pollution of the river was so great that the riparian owners insisted upon the withdrawal of the pot-ale from the sewers, and the distillers were then practically compelled to adopt the evaporation and incineration process now carried on. No objection was made to the waste liquors, other than pot-ale, being treated with the town sewage; and these are still dealt with by the Burgh authorities, a special rate for doing so being paid by each distiller.

The distilleries are connected with the purification works by cast iron-pipes, and as the stills are discharged, the pot-ale is run as hot as possible to one or other of two large receiving tanks in the works. Here the disposal of the pot-ale takes place in two stages. First it is evaporated to 7 or 8 per cent. of its original bulk, and is then in the form of a thick syrup. This syrup is dried in ovens till it becomes a black partially-charred mass.

The process is carried out as follows :—

From the receiving tanks the pot-ale is pumped into the first of a series of five large evaporating vacuum pans, so arranged that a graduated reduced pressure enables the waste heat from one unit to cause the pot-ale in the next unit to boil. In the first unit, boiling is brought about by the admission of steam from a boiler at slightly over atmospheric pressure, passing through a large number of tubes placed vertically in the bottom of the pan. Boiling takes place here at a temperature of 104° C. At suitable intervals, in practice about every half hour, the contents of one pan are sucked into the next, through the whole series, and a fresh charge of pot-ale is drawn into the first pan. The liquor in the second unit boils at about 92° C., in the third at 86° C., in the fourth at 78° C., and in the fifth and last at 55° C., where the pressure is reduced to about 3 inches of mercury. By a trapping arrangement, the accumulation of syrup in the last unit can be run off without interfering with the vacuum in the series. The plant was designed and erected by Messrs. Mirrlees, Watson & Co., Glasgow, who have taken great pains to make use of as much waste heat as is possible and to prevent radiation, and the fact that in practice each pound of fuel reduces from 22 to 23 lbs. of pot-ale to 7 per cent. of its original volume, proclaims the plant a very economical one. All the portions of the apparatus which come in contact with the pot-ale are made of gun-metal. During 1906, for five months, the evaporators dealt on an average with 80,000 gallons of pot-ale per week. In the season 1906, for a period of forty-seven weeks, an average of 70,000 gallons of pot-ale per week was evaporated to a thick syrup. The average amount of fuel consumed is thirty-two tons per week.

The distillate from the evaporating pans is cooled by admixture with about thirty volumes of water and then run into a small burn, which discharges into the Spey. Examination of the burn from time to time has generally shown the presence of more or less grey growths at or below the entry of the discharge pipe from the works. It was not anticipated that this distillate would be distilled water; but one hardly expected it to produce sewage fungus in a stream, after it had been previously diluted by some twenty to thirty times its volume of water. However, analysis of the undiluted effluent shows conclusively that in the last of the evaporating units in which the syrup is boiling under a very reduced pressure, some of it is carried over by splashing or in a finely divided form. At this stage of the operation the pot-ale is in its most concentrated form, and a little would cause the whole distillate to be of an objectionable character. Attempts are being made to minimise this splashing; but any serious reduction in the vacuum would naturally diminish the economical working of the plant.

An analysis was made of a sample of the distillate taken in March, 1907, at which time there were grey fungoid growths in the burn, and the following results were obtained :—

Ammoniacal nitrogen - - - - - - -	·036 per 100,000.
Albuminoid nitrogen - - - - . - - -	·048 „
Oxygen absorbed from $\frac{N}{8}$ permanganate in four hours at 27° C.	47·20 „

In this plant there is without doubt an example of the best that is done, in this country, in the way of partial destruction of pot-ale and recovery of a portion of its valuable matter, and by the combination of the four distilleries, capital outlay and working expenses are materially reduced.

The works have not been going long enough to give accurate figures of what the depreciation of the plant will be. It will, however, be seen that a large capital outlay and heavy annual charges are incurred in the disposal of pot-ale alone, and that the distillate produced, despite the care taken by the Manager, is still an objectionable liquid.

Incidentally, there is the accompanying nuisance caused by the smell imparted to the chimney gases, and the serious objection that the plant does not, and practically could not, dispose of the other waste liquors from the distilleries.

In the second stage of the treatment the thick pot-ale syrup is run into shallow iron pans, which are caused to traverse a long flue, through which the products of combustion from the boiler furnace and an auxiliary furnace are passing. These ovens are about 30 yards in length and the temperature at the entry is about 500° F., and at the exit 250–300° F. The bottom of the pan is covered with a layer of the syrup about an inch deep, and the rate of passage through the ovens is so arranged that the syrup has been reduced to a black charred mass by the time it has reached the exit end.

The material remaining in the pans is then chipped or scraped out and allowed to cool. Sufficient draught through the ovens is produced by a tall chimney and all the products of combustion pass into the air. The charred residue is ground to a fine powder and meets with a ready sale as a manure. About eight tons of it are produced per week and it sells at about £4 10s. a ton, free on rail at Rothes.

The Manager has kindly provided the following figures as to the cost of this process :—

The total capital invested, including working capital, is £14,000, of which, roughly speaking, buildings account for £6,000 and plant £7,000.

During the season 1906–7, a period of forty-seven weeks, about 2,900,000 gallons of pot-ale, together with 250,000 gallons of leakage water, were evaporated and incinerated, yielding 300 tons of saleable manure. The average working hours per week were fifty-one under steam and fifty-seven in the drying oven.

This amount of pot ale is equivalent to approximately 210,000 bushels of malt, or an average of about 4,400 bushels per week for forty-seven weeks.

The average price of the manure sold was £4 15s. per ton, the actual sales producing £1,435 during the period.

The costs may be apportioned thus :—

	£
Wages and salaries - - - - - - - - - - -	564
Coal and oil - - - - - - - - - - -	1,000
Repairs - - - - - - - - - - - - -	26
All other expenses - - - - - - - - - - -	500
	2,090
Less cash for manure - - - - - - - - - -	1,435
Leaving a net loss of - - - - - - - - - - -	£655 per annum.

The average price of coal was 17s. 8d. per ton.

The management does not know what the depreciation on the plant may be. The plant has been surveyed recently, and the report is to the effect that there is at present (1907) very little evidence of depreciation having taken place during the sixteen months' working.

As regards this item of depreciation, the only instance for comparison exists at Glen Dullan distillery. Here a similar evaporating plant, but on a smaller scale, was found to require practical renovation at the end of five years' working.

It will be noticed that it requires four tons of fuel to produce 1 ton of saleable manure, so that any serious rise in the cost of fuel would considerably increase the cost of the manure and consequently the loss on marketing it.

On the basis of the data supplied, the total annual cost of such a plant, allowing 10 per cent. depreciation on the evaporators, may be taken as follows :—

	£
Actual loss on manure - - - - - - - - - -	655
10 per cent. depreciation on plant - - - - - - - -	700
2 „ „ „ buildings - - - - - - - -	120
4 „ interest on capital - - - - - - - - -	560
A total of - - - - - - - - -	£2,035 per annum.

Robert D. Littlefield.

December, 1908.

APPENDIX III.

NOTES ON THE WORKING OF THE COLEBURN FILTER AND THE MORTLACH CONTACT BEDS AND ON THE RESULTS OBTAINED FROM THEM.

In a paper entitled "The Composition and Disposal of Burnt Ale and of other Waste Liquids of Whisky Distilleries" (*Journ. Soc. Chem. Ind.*, May, 1901), Professor James Hendrick gives the results of an extended study of distillery waste liquors, both as regards their composition and their utilization or purification. He records some successful small experiments on the bacterial purification of those waste liquors, which were the outcome of this closely reasoned study—experiments carried out on practically the lines afterwards adopted by the Commission at Coleburn. Had those experiments been followed up at the time on a larger scale, there can be no reasonable doubt that the practical bacterial purification of distillery waste liquors would have been achieved by him.

Table A (below) gives a few data regarding the amounts of oxygen required by pot-ale and steep water for oxidation; from it the following notes may be taken:

A sample of pot-ale (made 3rd June, 1907, and kept in the still until 26th June), drawn without its sediment, gave the following figures:—

—	Parts per 100,000.
"Oxygen absorbed" from $\frac{N}{8}$ permanganate in four hours at 27° C. (80° F.) - - - - - -	1,183
Dissolved oxygen taken up from water, for complete oxidation - - - - - - - -	4,576 (Average of three concordant estimations).

Four samples of limed liquor, made from pot-ale diluted with water to ten times its original volume and settled, gave:—

—	Parts per 100,000.
"Oxygen absorbed" in four hours (98·2, 84·8, 69·4 and 66·4*) - - - - - - - -	79·7
Dissolved oxygen required for complete oxidation (461, 202, 252 and 408*) - - - - -	330

One sample of limed liquor, made from steep water only, without any dilution, gave:—

—	Parts per 100,000.
"Oxygen absorbed" in four hours - - - -	54·5
Oxygen required for complete oxidation - - -	470·6

From these figures the *provisional* conclusions may be drawn that—

1. Settled limed liquor made from pot-ale and water alone, *i.e.*, diluted with water to ten times the original volume of the pot-ale, will require for its oxidation about three and a half times as much oxygen as the same volume of an average strength sewage.

2. Settled limed liquor made from mixed steep water alone,† without dilution, will require about five times as much oxygen as an average sewage.

3. Limed liquor made from pot-ale plus the normal proportions of spent lees and wash water will require about four and a half times as much oxygen as sewage.

With regard to the relative rates at which the liquors take up oxygen, no strictly comparative experiments have been made with distillery waste liquors and sewage liquors, but the following data throw some light upon the point.

The *degree* of oxidation, by "strong" (*i.e.* $\frac{N}{8}$) permanganate in four hours, of settled limed liquor made from pot-ale and water alone, or even from pot-ale plus the proportionate volumes of spent lees and wash water, is greater than in the case of sewage liquors, *i.e.*, a larger *percentage* of the organic matter in the distillery waste liquors

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* This last sample was made from pot-ale, spent lees and wash water. The organic matter in the spent lees and the wash water being, however, small, comparatively speaking, the sample has been included with those made from pot-ale alone.

† *Note.*—This refers to quiescent steeping, using two or occasionally three lots of water, and not to continuous flow steeping.

TABLE A.

Coleburn Pot-ale and Limed Liquor.

The following Table A gives a few data with regard to the amounts of oxygen required by pot-ale and steep water for oxidation.

Nature of sample	Date of aeration.	Total nitrogen (unoxidised).	Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C.		Suspended solids.	Dissolved oxygen taken up from water in	→Days.	Dilution.	Dissolved oxygen taken up from water, corrected for gas evolved, in	→Days.	Dilution.	Ratio of dissolved oxygen absorption in 5 to 7 days to complete dissolved oxygen absorption.	Four hours' factor for "strength" formula, after allowing for the oxidation of the ammoniacal and organic nitrogen.	Notes.
			At once.	In 4 hours.										
Parts per 100,000.														
POT-ALE.														
Pot-ale (A) - -	June 28/07.	156·9	109·2	1,184·0	Turbid, but with no visible suspended solids.	729†	8	1 in 1,000	4 470‡	105	1 in 10,000	—	3·18	These four rows of figures refer to the same sample of pot-ale. It was made on June 3rd, 1907, and kept in the still. The sample analysed was taken from the still on June 26th, without stirring. The limed samples were made in the laboratory and the precipitated sludge was not removed. The figures of analysis ought therefore to be the same for all four samples, subject to errors of experiment.
do. duplicate (B)	June 28/07.	156·9	109·2	1,184·0		729†	8	1 in 1,000	4,573‡	305	1 in 10,000	—	3·27	
Same pot-ale, limed, and the precipitated sludge left in the liquid (A) - -	June 28/07.	156·9 *	106·1	1,193·0	Not determined.	736†	8	1 in 1,000	4,686‡	105	1 in 10,000	—	3 36	
do. duplicate (B) -	June 28/07.	156·9 *	106·1	1,193·0		736	8	1 in 1,000	4,187‡	305	1 in 10,000	—	2·92	
LIMED LIQUOR.														
No. 18.—Limed liquor made from pot-ale, which would be at least six weeks old, probably older - - - -	August 1/06.	11·97	9·03	98·16	—	249·5	7	1 in 500	461·0	659	1 in 1,000	7 days. Complete. 1 : 1·85	4·25	
No. —.—Limed liquor made from pot-ale, less than a week old - -	Feb. 8/08.	6·70	5·11	84·75	4·8	—	—	—	202·0	107	1 in 500	—	2·03	
No. 49.—Limed liquor made from a proportionate mixture of pot-ale, spent lees, and wash water - - -	May 17/07.	11·04	2·82	66·40	4·1	159·5	5	1 in 250	408·0	164	1 in 1,000	5 days. Complete. 1 : 2·56	5·40	
No. —.—Limed liquor made from fresh pot-ale only - - -	May 26/08.	7·61	5·31	69·40	8·9	—	—	—	251·7	146	1 in 750	—	3·13	
No. 40.—Limed liquor made (practically speaking) from steep water -	Oct. 25/06.	7·38	4·94	54·45	Almost none.	171·4	5	1 in 250	470·6§	151	1 in 1,000	5 days. Complete. 1 : 2·75	8·0	

* The nitrogen was not actually determined after liming, but was assumed to be the same as before liming.

† Those figures are not quite correct, but nearly so (*see* next note, for the dilutions used). The dilutions were, however, inadequate. Had there been more oxygen present to be drawn upon, there would certainly have been much more taken up in eight days (*cf.* figures below).

‡ The original dilutions were 1 in 1,000, made on June 28th, 1907; but on July 5th and 8th the bottles were opened and the dilutions made 1 in 10,000. For this reason the figures obtained for complete dissolved oxygen absorption (4,470, etc.), are not quite correct, but nearly so.

§ This dilution was done in an unjointed bottle. All the others given in this table were done in jointed bottles.

is oxidised in this test. With regard, however, to the ratio of oxidation by permanganate in four hours to that by oxygenated water in five days, the ratio is lower in the case of limed liquor from pot-ale. The following average figures, from a fair number of samples, may be taken broadly as exemplifying this :—

——	Ratio of Oxidation.	
	Permanganate in four hours.	Oxygenated water in five days.
Settled limed liquor, prepared from pot-ale, water and lime - - - - - - - -	1	1·6
Septic liquor from sewage - - - - -	1	2·5
Precipitation liquor from sewage - - - -	1	2·2

While thus the immediate oxidation by permanganate of pot-ale limed liquor is greater than that of sewage liquors, the ratio of oxidation by permanganate in four hours to that by oxygen dissolved in water in five days is lower. From this it would seem reasonable to draw the broad inference that, unit for unit of oxidisable organic matter, limed liquor made from pot-ale and sewage liquor do not differ greatly as regards the rate at which they might be expected to undergo oxidation on a biological filter.

We have had much less experience with limed liquor made from steep water alone, but what we have had goes to show that, for equal organic strength, limed steep water is relatively harder to oxidise than diluted limed liquor from pot-ale.

If the figures of analysis of pot-ale or of limed liquor made from pot-ale (or from pot-ale plus the other distillery waste liquors) be compared with those of sewage, septic liquor or precipitation liquor, what will immediately be seen will be the much greater proportion of carbonaceous as against nitrogenous matter in the former case (the four hours "oxygen absorbed" test being taken as a relative measure of the carbonaceous matter). This is shown by the figures :—

——	Limed Steep Liquor.		Very strong Steep Water.	Limed Pot-ale (14 samples).
	8th Oct., 1906.	22nd Oct., 1906.	21st March, 1906.	1907–08.
Total nitrogen - - - - - -	4·48	7·38	10·29	6·51
"Oxygen absorbed" at once - - -	6·80	4·94	23·24	—
„ „ in four hours - -	86·07	54·45	128·54	71·29
Ratio—Total nitrogen : "Oxygen absorbed" in four hours - - - - -	1 : 19	1 : 7·4	1 : 12·5	1 : 11

In crude sewages this ratio is from 1 : 1 to 1 : 2·5 and rarely higher.

In septic liquors this ratio is usually about 1 : 1 (say 1 : 0·5 to 1 : 1·5).

In precipitation liquors this ratio is usually about 1 : 1 (it may rise to 1 : 3 when much trade refuse is present).

As stated in the Fifth Report of the Commission, page 150, the loss of nitrogen from sewage or sewage liquor which has been purified by filtration through soil or through biological filters, amounts to about 60 per cent. in the case of land treatment and to about 30 to 50 per cent. in the case of artificial filters. In the case of distillery waste liquors this percentage loss is very much greater. Thus, at Coleburn, between November, 1907, and June, 1908, fourteen samples of the limed liquor treated gave the average figure of 6·53 parts of total nitrogen per 100,000, while the average figure for the corresponding fourteen effluents was only 1·08. Here, therefore, there was a disappearance of 83 per cent. of the nitrogen.

This is instructive as illustrating the care which is required in interpreting analytical results, with reference to the point,—how much significance is to be attached to the quantity of nitrate present in an effluent?

As further illustrating how nitrate is used up in a filter, reference may be made to a special experiment carried out at Coleburn in June, 1908, when to the limed liquor going on to the filter there was added (as nitrate of soda) 10 parts of nitric nitrogen per 100,000 of liquor for two days and 20 parts for the third day. The figures for total nitrogen going on in the limed liquor and coming out in the effluent were as follows :—

Parts per 100,000.	Total Nitrogen.	
	Limed Liquor.	Effluent.
First day - - - - - - - -	17·1	2·35
Second day - - - - - - - -	16·5	2·40
Third day - - - - - - - -	26·6	1·95
Fourth day - - - - - - - -	Say, 6 to 7*	2·18

* Not estimated, but inferred from the preceding estimation.

Incidentally, the addition of nitrate of soda had the effect of causing a large "flush-out" of solids from the filter, possibly by the absorption, in the first instance, of some nitrate by the organic solids in the filter, and its subsequent decomposition, with evolution of gas.

At the time when this experiment was made, the filter was purifying the limed liquor, with the production of the usual well oxidised effluent, through the aid of the oxygen of the air alone. The oxygen added in the form of nitrate of soda was relatively small in amount (from 30 to 60 parts per 100,000, as against 300 to 400 parts used up from the air), but still it *was* utilized by some of the organic matter of the filter, in addition to the usual atmospheric oxygen.*

WORK DONE BY THE COLEBURN (PERCOLATING) FILTER.

In the fifth Report of the Commission, Appendix IV., in the papers dealing with "Strength" of sewage liquors and with work done by filters, reasons are adduced for the adoption of certain formulæ for arriving *approximately* at the "strength" or degree of oxidizability of sewage liquors and effluents from the ordinary figures of analysis and, with this, of calculating the amount of purification effected per cube yard of filter.†

Applying the same argument to the liquors from distillery waste, we should probably be not far from the truth if we made use of the following "strength" formula for settled limed liquor made from pot-ale, water and lime only (though it will be desirable to accumulate further data upon the "strength" of distillery waste liquors generally) :—

(Ammoniacal + Organic Nitrogen) × 4·5 + "Oxygen absorbed" in four hours × 3·5.

For well purified effluents from distillery waste, the formula adopted for filter effluents from sewage would apply.

Period covered by the Fish Experiments, during which the Filter was treating Limed Liquor made from Pot-Ale.

During the season from November, 1907, to June, 1908, the Coleburn filter was treating *continuously* 20 gallons per cube yard per day of settled limed liquor, made from 1·7 gallons of pot-ale only. Fourteen samples of this, drawn between 29th November, 1907, and 23rd May, 1908, gave the average figures of analysis :—

—	Parts per 100,000.
Total Nitrogen - - - - - - - -	6·51
"Oxygen absorbed" from Permanganate in four hours at 27° C. - - - - - - -	71·29

The "Strength" of the liquor, as calculated by the above formula, was therefore 279·2.

Fourteen corresponding samples of the effluent, as entering the salmon hatchery, *i.e.*, after passing through the small straining filter, gave the following average figures on analysis :—

—	Parts per 100,000.
Ammoniacal Nitrogen - - - - - -	0·04
Albuminoid Nitrogen - - - - - -	0·14
Nitric Nitrogen - - - - - - - -	0·68
"Oxygen absorbed" at 27° C. *at once* - - -	0·46
" " " *in four hours* - -	1·82
Dissolved Oxygen taken up from water at 18° C. in forty-eight hours - - - - - - - -	0·28
Dissolved Oxygen taken up from water at 18° C. in five days - - - - - - - -	0·61
Suspended solids in effluent, *as issuing from filter*‡ (about)	2·0 (this is an estimate)
Containing Volatile solids - - - - "	1·6 " "

A glance at the above figures of analysis is sufficient to show that, coming as it did from such a strong organic liquor, this effluent was very well oxidised. The volatile matter of the suspended solids in the filter effluent was, however, capable of taking up an appreciable quantity of oxygen, something like four parts by weight of oxygen for each part of volatile matter.§

The oxidisability of the effluent as a whole, therefore, including the solids and giving credit for the nitrate present, would be approximately represented by the figure 6, as against 279·2 for the limed liquor going on to the filter.

The work done by the filter, *working continuously*, between November, 1907, and June, 1908, was thus (279·2 − 6) = 273·2 × 20 = 5,464 units of purification per cube yard per twenty-four hours.

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* A corresponding experiment was made with the addition of sulphate of ammonia (in place of the nitrate of soda) to the limed liquor. The analytical figures of this experiment are given in Appendix V. The experiment was, however, not carried quite far enough, so the results are not discussed here.

† *Note* :—A few inches of coke at the top of the Coleburn filter were renewed at intervals of about five to eight weeks. The oxygen required to oxidize the solids and the growths which accumulated there ought, strictly speaking, to be taken into account in calculating the purification effected by the filter, but we have no data which allow of this. The result would of course be to reduce to a small extent the figures given for units of purification per cube yard of filter.

‡ The effluent entering the fish tank contained almost no suspended matter. Apart from this, the two effluent may be taken as being practically alike.

§ Deduced from two good experiments.

Periods during which the Filter was treating Limed Liquor made from Steep Water only.

1.—After the filter had become fairly matured, it treated *limed steep water* from September 25th to November 3rd, 1906, at an average rate of 1,100 gallons of limed steep liquor per twenty-four hours, or 5·2 gallons per cube yard. This constituted the whole output of the distillery at the time.

Eleven samples of this liquor gave the average figure 56·3 for "Oxygen absorbed" in four hours.

Only two estimations of total nitrogen were made, and these bore totally different ratios to the corresponding figures for "Oxygen absorbed," thus :—

——	Total Nitrogen.	"Oxygen absorbed" in four hours.	Ratio.
Sample of 8th October - - - - - -	4·48	86·07	1 : 19
Sample of 22nd October - - - - - -	7·38	54·45	1 : 7

Any accurate estimate of the average total nitrogen in this liquor is therefore impossible, without further data, but it may be assumed tentatively to be about 6·0.

If we take the "Strength" formula of the limed steep liquor, pending further investigation, as :—

(Ammoniacal + Organic Nitrogen) × 4·5 + "Oxygen absorbed" in four hours × 8·0 (*cf.* pp. 41 and 42),

the strength of the above liquor would be 477.

The filter effluent for the same period (25th September to 3rd November, 1906) gave the following figures of analysis :—

Ammoniacal nitrogen - - - - - - - - - - -	0·04 (3)
Albuminoid nitrogen - - - - - - - - - - -	0·14 (3)
Nitric nitrogen - - - - - - - - - - - -	0·84 (5)
"Oxygen absorbed" at 27°C. in four hours - - - - - - -	2·56 (11)
Suspended solids - - - - - - - - - - - -	4·5 (5)
Volatile matter in these solids - - - - - - - - -	3·6 approx.

The figures in brackets indicate the number of estimations in each case.

The calculated oxidisability of this effluent, from the rather meagre data, would be about 13.

The work done by the filter during this period was thus, very approximately, 477 — 13 = 464 × 5·2 = 2,413 units of purification per cube yard per day.

The filter could obviously have done much more than this, had there been at the time a larger volume of distillery waste liquor to purify.

2.—From November 7th to December 4th, 1908, the filter again treated limed liquor made from steep water alone (the whole of the steep water produced), at the rate of 8 to 9 gallons per cube yard per day, for six days in the week.

The limed liquor treated gave the following figures (average of four analyses) :—

Total Nitrogen (4·53 to 9·81) - - - - - - - - - -	6·9
"Oxygen absorbed" at. 27° C. in four hours (55·5 to 96·8) - - -	74·1

Its calculated strength, according to the tentative formula given above, would therefore be 644.

The filter effluent for the same period gave the figures (average of four analyses) :—

Ammoniacal nitrogen - - - - - - . - - - - -	0·04
Albuminoid nitrogen - - - - - - - - - - -	0·19
Total organic nitrogen - - - - - - - - - -	0·39
Nitric nitrogen - - - - - - - - - - - - -	1·23
"Oxygen absorbed" at 27° C. in four hours - - - - - -	2·92
Incubator test (by smell) - - - - - - - - - -	All passed.
Dissolved oxygen taken up from water at 18° C. in 48 hours - - -	0·23
" " " " at 18° C. in five days - - -	0·57
Suspended solids - - - - - - - - - - - say*	0·5
Volatile matter in these solids - - - - - - - say*	0·4

As is obvious from the figures of analysis, the effluent was an excellent one. The calculated oxidisability of this effluent (including the suspended solids and giving credit for the nitrate present) would be about – 1.

The work done by the filter during this period was thus, approximately :—
644 + 1 = 645 × 8·5 = about 5,480 units of purification per cube yard per day, working six days in the week.

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* Estimated from the centrifuge figures.

Periods during which the Filter was treating Limed Liquor made from Pot-ale plus the proportionate quantities of the other Distillery Liquors, i.e., *Steep Water, Spent Lees and Wash Water.*

A.—From November 3rd, 1906, to March 7th, 1907, the filter treated per cube yard per day, for six days in the week, 20 gallons of limed liquor made from :—

2 gallons of pot-ale ;
3 gallons of steep water ;
2 gallons of spent lees and wash water ; and
13 gallons of water.

From November 3rd until the end of 1906, only short analyses of the limed liquor under treatment were made, but these, when compared with more detailed analyses done subsequently, showed that the liquor was of very constant strength throughout this period. Between November 8th and December 22nd, seventeen samples gave an average figure of 95·9 for "oxygen absorbed" in four hours.

Between January 9th and March 4th, 1907, the limed liquor gave the following figures :

"Oxygen absorbed" in four hours	96·9 (8)
Albuminoid nitrogen	5·8 (8)
Total nitrogen - (say)	9·0 *

If we take the "strength" formula of the above mixed liquor for the period "A" as being approximately :—

(Ammoniacal + organic nitrogen) × 4·5 + "oxygen absorbed" in four hours × 4·5,

then this liquor had a strength of 477.

The effluent during period "A" gave the figures :—

Ammoniacal nitrogen	0·18 (8)
Albuminoid nitrogen	0·33 (8)
Nitric nitrogen	0·51 (8)
"Oxygen absorbed" at 27° C. in four hours	3·29 (8)
Suspended solids - (say)	2·0 †
Containing volatile matter - (say)	1·6 †

The calculated oxidisability of this effluent, including the estimated solids and giving credit for the nitrate, would be about 8·5.

The work done by the filter during this period was thus, approximately, 477 − 8·5 = 468·5 × 20 = 9,370 units of purification per cube yard per day, for six days in the week.

B.—From March 7th until the end of June, 1907, the filter treated per cube yard, per day, 20 gallons of limed liquor made from :—

2 gallons of pot-ale ;
5 gallons of spent lees and wash water together ; and
13 gallons of water.

Between March 14th and June 19th the above limed liquor gave the figures :—

"Oxygen absorbed" in four hours	87·7 (10)
Albuminoid nitrogen	5·5 (10)
Total nitrogen - (say)	9·0 *

Taking the "strength" formula for this period "C" as being approximately :—

(Ammoniacal + organic nitrogen) × 4·5 + "oxygen absorbed" in fours hours × 3·5,

this liquor had a strength of 347.

The effluent during period "B" gave the figures :—

Ammoniacal Nitrogen	0·07 (10)
Albuminoid Nitrogen	0·24 (10)
Nitric Nitrogen	1·61 (10)
"Oxygen absorbed" in four hours at 27° C.	2·14 (10)
Solids in suspension (say)	4·0†
Containing volatile matter (say)	3·2

The calculated oxidisability of this effluent, including the estimated solids and giving credit for the nitrate, would be about 15.

The work done by the filter during period "B" was thus, approximately :—347 − 15 = 332 × 20 = 6,640 units of purification per cube yard per day, working six days a week.

---

* This figure for total nitrogen is an estimate.
† This is an estimate.

PURIFICATION OF DISTILLERY WASTE ON CONTACT BEDS AND QUALITY OF THE EFFLUENT PRODUCED.

1. *Treatment of Limed Pot-ale.*

Our data as regards contact beds are necessarily much fewer than those for percolating filters. In attempting to make an estimate of the oxidation effected at Mortlach by the contact beds treating limed pot ale, it will be best to restrict ourselves in the meantime to the short period from 1st to 24th June, 1908. During that time the beds, which had been gradually maturing, were doing much more work than before, treating at the rate of 20 gallons per cube yard per day of 1 in 10 limed pot-ale (= 2 gallons pot-ale per day, less the precipitated sludge).

This 1 in 10 limed liquor gave the following figures :—

" Oxygen absorbed " in four hours	75·0 (11)
Total nitrogen (inferred)	7·0‡

The calculated strength according to formula :—(Ammoniacal + organic nitrogen) × 4·5 + (" oxygen absorbed " in four hours × 3·5) is 294.

The final (sixth contact) effluent gave :—

" Oxygen absorbed " in four hours	4·89 (19)
Total nitrogen, unoxidised	(say) 0·6*

The calculated strength or oxidisability, according to the same formula as was used for the limed liquor, is 20.‖

The work done was thus, *approximately* :—294 − 20 = 274 × 20 = 5,480 units of purification per cube yard per twenty four hours, but the final effluent was putrescent on incubation and required a little further treatment to make it satisfactory, *per se*.

---

* This is an estimate.

† This is a very rough estimate, allowing for the " Spring out-flush " of solids.

‡ This figure is inferred from the ratio of " oxygen absorbed " in four hours to total nitrogen (10·9 : 1) in five samples of the Mortlach limed liquor.

‖ *Note.*—A sixth contact effluent drawn on 7th April, 1908, gave the figure 3·12 for " oxygen absorbed " in four hours, and it actually took up 9.4 parts of dissolved oxygen from water in 192 days. For this reason the usual formula for well oxidised effluents cannot be employed here, and the data are not sufficient to give the true formula.

TABLE B.

Mortlach Contact Beds.

The following Table B gives the results of the examination of a series of *corresponding* samples drawn from the Mortlach Contact Beds on April 7th, 1908 :—

Analysis of a series of *corresponding* samples drawn from the Mortlach Contact Beds on April 7th, 1908. At this time the beds were treating limed pot-ale only (5 per cent. pot-ale), at the rate of 0·33 gallon pot-ale or 6·6 gallons limed liquor per cube yard of contact bed per day, for six days in the week.

Analyses made April 9th and 10th, 1908.	Unoxidised nitrogen.	Oxidised nitrogen.	Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C.		Suspended solids.	Dissolved oxygen absorption in :—			Dilution in tap water for the long aerations.	Ratio of dissolved oxygen absorption in five days to complete dissolved oxygen absorption.	Four hours' factor for "strength" formula, after allowing for the oxidation of the ammonia and organic nitrogen, and giving credit for the nitrate in the effluent.	Percentage purification, calculated on the dissolved oxygen absorption.	Percentage purification, calculated on the "oxygen absorbed" from permanganate in four hours.
			At once.	In 4 hours.		Forty-eight hours.	Five days.	192 to 221 days (corrected for gas evolved).					
Limed liquor - -	3·43	0·0	2·92	44·26	3·5 {2·9 Vol. 0·6 Non.	35·1	64·2	203·2	1 in 750	1 : 3·2	4·2	—	—
1st contact effluent -	3·34	0·0	1·49	30·91	2·7 {2·5 Vol. 0·2 Non.	34·8 + x*	52·0	124·0	1 in 500	1 : 2·4	3·5	39·0	30·1
2nd contact effluent-	2·96	0·0	1·02	30·51	2·6 {2·4 Vol. 0·2 Non.	30·0	48·8	106·8	1 in 400	1 : 2·2	3·1	47·4	31·1
3rd contact effluent -	1·88	0·37	1·98	21·62	Say 1·9	16·5 + x × $\frac{2}{3}$†	34·7 + x*	82·8‡ ap.	1 in 300	1 : 2·4 ap.	3·5	59·3‡ ap.	51·2
4th contact effluent -	1·00	0·22	1·08	13·63	„ 0·9	17·2 + x × $\frac{2}{3}$	19·6	52·1	1 in 200	1 : 2·7	3·5	74·4	69·2
5th contact effluent -	0·69	0·06	0·54	8·13	„ 1·1	8·0 + x × $\frac{2}{3}$	9·8	26·6	1 in 100	1 : 2·7	2·9	86·9	81·6
6th contact effluent -	0·44	0·20	0·54	3·12	„ 0·6	2·55 × $\frac{2}{3}$	3·1	9·4	1 in 50	1 : 3·0	2·7	95·4	93·0

* "+ x" denotes that the oxygen in solution was exhausted, so that the figure given is below the true value.

† "× $\frac{2}{3}$" means that the actual "aeration" was spread over three days, instead of two.

‡ Owing to an error, this figure is not *absolutely* correct, but it is so nearly right that it may be taken with the others.

§ Those four last figures for suspended solids are deduced approximately from the centrifuge figures.

TABLE C.

Table C. gives similar sets of figures for *corresponding* samples of limed liquor, 4th contact bed effluent and 6th contact bed effluent, drawn on March 17th, 1908. The liquor treated in the beds was limed pot-ale (5 per cent. pot-ale) at the rate of 0·33 gallon pot-ale or 6·6 gallons limed liquor per cube yard per day, for six days in the week.

Analysis made March 19th, 1908.	Unoxidised Nitrogen.	Oxidised Nitrogen.	Oxygen absorbed from $\frac{N}{8}$ permanganate at 27° C.		Suspended Solids.	Dissolved oxygen absorption in			Dilution in tap water for the long aerations.	Ratio of dissolved oxygen absorption in five days to complete dissolved oxygen absorption.	Four hours factor for "strength" formula, after allowing for the oxidation of the ammonia and organic nitrogen.	Percentage purification, calculated on the dissolved oxygen absorption.	Percentage purification, calculated on the "oxygen absorbed" from permanganate in four hours.
			At once.	In 4 hours.		Forty-eight hours.	Five days.	249 to 265 days (corrected for gas evolved).					
Limed liquor - -	3·76	—	3·05	50·44	2·9 { 2·7 Vol. 0·2 Non-vol.	36·0	64.0	206·7	1 in 1,000.	1 : 3·2	3·8	—	—
4th contact effluent -	0·83	0·02	1·02	10·10	Trace.	7·35	13·6	52·6	1 in 200.	1 : 3·9	4·8	74·6	80·0
6th contact effluent -	0·25	0·0	0·31	1·63	Trace.	0·31	0·91	8·47	1 in 50.	1 : 9·3	4·5	95·9	96·8

Table B brings out the following interesting points:—

1. "*Strength*" *formula*:—

The "Strength" formula for the above limed liquor would be:—
(Ammon. + Organic Nitrogen) × 4·5 + ("Oxygen absorbed" in four hours × 4·2).

For the first four effluents it might be taken at:—
(Ammon. + Organic Nitrogen) × 4·5 + ("Oxygen absorbed" × 3·4).

For the last two effluents, at:—
(Ammon. + Organic Nitrogen) × 4·5 + ("Oxygen absorbed" × 2·8).

From Table C, the "strength" formula for the limed liquor would be practically the same, viz.:—(Ammon. + Organic Nitrogen) × 4·5 + "Oxygen absorbed" in four hours × 3·8. For the fourth and sixth contact effluents in Table C, however, the permanganate multiplication factor is much higher, viz., 4·8 and 4·5, as against 3·5 and 2·7 in Table B.

2. From one half to one third of the total oxidisable organic matter in this limed liquor was oxidised by the oxygen of diluting water in five days.

3. The figures for percentage purification, as calculated respectively on the dissolved oxygen absorption and on the "oxygen absorbed" from permanganate in four hours, differ considerably in the first effluents, but with increasing purification they gradually approximate to one another. Had the purification been carried a little further, so as to produce a good final effluent *per se*, the calculated percentage purification would have been almost the same in both cases.

It is therefore safe to say that the four hours "oxygen absorbed" figure may be relied upon to give almost the true percentage purification in the case of *well purified* effluents from contact beds treating limed liquor made from pot-ale.

2. *Treatment of Limed Steep Water* (*from quiescent steeping*).

From the commencement of the distilling season of 1908–9, the contact beds at Mortlach have been treating limed liquor made from steep water only, at the rate of 20 gallons of limed liquor per cubic yard per day, for six days in the week. The steep water itself constituted during November and December about 60 per cent. by volume of the total limed liquor, the remainder being lime water and water. During the time this treatment was kept under observation the steep water became progressively stronger, the last sample analysed giving the very high figure of 84·5 for "oxygen absorbed" from permanganate in four hours.

Five corresponding sets of limed liquor, third contact bed effluent and sixth contact bed effluent were drawn between November 16th and December 22nd, 1908, and these gave the following average figures on analysis (the figures in brackets indicate the number of estimations in each case):—

Limed Liquor.	Parts per 100,000.
Total nitrogen (3·36 to 9·18)	5·60 (5)
"Oxygen absorbed" in four hours (25·73 to 84·50)	50·95 (5)

The calculated "strength" of this liquor, according to the tentative formula given on p. 45, viz.:—

(Ammon. + Organic Nitrogen) × 4·5 + "Oxygen absorbed" in four hours × 8·0

would therefore be 433 approximately.

Third Contact Effluent.	
Ammoniacal nitrogen	1·02 (5)
Albuminoid nitrogen	1·77 (5)
Total organic nitrogen	2·96 (5)
"Oxygen absorbed" at 27° C. *at once*	4·47 (5)
" " " *in four hours*	39·04 (5)
Solids in suspension	(say) 4·5*
Solids by centrifuge (Vols.)	9·0 (4)
Dissolved oxygen taken up from water at 18° C.:—	
In forty-eight hours	63·2† (5)
In five days	101·1† (5)

The calculated oxidisability of this effluent, making use of the same formula as for the limed liquor treated, would be about 329. The percentage purification from the three contacts, as calculated on the "oxygen absorbed" in four hours, is 34.

Sixth Contact Effluent.		
Ammoniacal nitrogen	0·10	(5)
Albuminoid nitrogen	0·43	(5)
Total organic nitrogen	0·90	(5)
Oxidised nitrogen	0·0	(5)
"Oxygen absorbed" at 27° C. *at once*	1·48	(5)
" " " *in four hours*	10·12	(5)
Incubator test (by smell)	§ All failed.	(5)
‡ Dissolved oxygen taken up from water		

The calculated oxidisability of this effluent, again using the same formula as for the limed liquor, is 85. The percentage purification, as calculated on the "oxygen absorbed" in four hours, is 80. The final effluent in this case was not sufficiently purified to allow of anything like a true estimate being made of the "work done" by the filter. It should be added that this effluent received its final purification over land.

It is evident from the figures of analysis that, in the treatment upon a series of six contact beds of limed liquor made from strong steep water only, the liquor should be so diluted as to give a figure for "oxygen absorbed" in four hours which does not much exceed 25; even then the final effluent will only be of moderate quality. Limed steep water is thus much more difficult to oxidise upon contact beds than limed liquor made from pot-ale showing an equal "oxygen absorption" from permanganate (*cf.* "Strength" of limed liquors).

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* This is a very rough estimate.

† One interpolation in each case.

‡ The figures for dissolved oxygen absorption in forty-eight hours and five days cannot be given, as in several cases too small dilutions were used.

§ Taken for granted in the case of the last sample.

TABLE D.

The purification effected at Coleburn and Mortlach over the various periods may be shortly summarised in the following Table :—

Period.	Nature of liquor treated.	Calculated strength of liquor treated.	Calculated oxidisability of effluent (including solids and giving credit for nitrate).	Gallons of liquor treated per cube yard of filter per day.	Units of purification effected per cube yard of filter per day.	General quality of effluent.	Percentage purification, calculated on the atmospheric oxygen used up.	Percentage purification, calculated on the "oxygen absorbed" in four hours.
Coleburn Filter.								
25th September to 3rd November, 1906.	Settled limed liquor from steep water only.	477	13	5·2	2,413*	Good.	97·3	95·6
7th November to 4th December, 1908.	Settled limed liquor from steep water only.	644	−1	8 to 9 (say, 8·5)	5,480	High Class.	100	96·1
3rd November, 1906, to 7th March, 1907.	Settled limed liquor from pot-ale plus all the other distillery liquors.	477	8·5	20	9,370†	Good.	98·2	96·6
8th March to end of June, 1907.	Settled limed liquor from pot-ale, spent lees and wash water.	347	15	20	6,640†	Very good apart from solids.	95·7	97·6
November, 1907, to June, 1908.	Settled limed liquor from pot-ale only.	279	6	20	5,460‡	High class.	97·8	97·4
Mortlach Contact Beds.								
1st to 24th June, 1908.	Settled limed liquor from pot-ale only.	294	say, 20	20	5,480§	Poor. Not quite sufficiently purified.	93·2	93·5

* Working on the average about ten hours a day for six days in the week.

† Working continuously for six days a week.

‡ Working continuously.

§ Working twelve hours a day for six days in the week.

Conclusions.

1. The main conclusion to be drawn from the work at Coleburn and Mortlach is that the purification of distillery waste liquors on biological filters does not differ materially, as regards the aggregate oxidation effected, from the purification of sewage liquors. The distillery liquors being, however, so much the stronger, organically, require to be treated in proportionately smaller volumes, after being sufficiently diluted.

2. *Quality of the Coleburn effluent.*—Apart from the salmon experiments, than which a more crucial practical test could not, we think, be devised, the analytical results show that the Coleburn filter, treating *continuously* limed liquor made from pot-ale alone, at the rate of 20 gallons of limed liquor per cube yard per day (equivalent to 1·7 gallons of pot-ale), produced an effluent of very high class.

When treating, on six days per week, 20 gallons of limed liquor made from 2 gallons of pot-ale, together with the proportionate volumes of spent lees and wash water, the effluent was very good.

When treating, on six days per week, 20 gallons of limed liquor made from 2 gallons of pot-ale plus the proportionate volumes of steep water and the other distillery liquids, the effluent was also good, though not quite of such high class.

3. A percolating filter plant, of sufficient size to cope with the mixed distillery liquors, is more than large enough to purify the steep liquors produced in the early part of the distilling season. When the steep liquor is very strong, it would be well to dilute it with water, so that the four hours "oxygen absorbed" figure does not exceed about 50.

4. *Contact Beds.*—Our data as regards the treatment of distillery waste on contact beds are much fewer than those for percolating filters. Taking them, however, in conjunction with the experience which we have had in the treatment of sewage liquors, it is safe to say that a cube yard of contact bed cannot be expected to deal with as much distillery waste as a cube yard of percolating filter. Still, with a proper system of contact beds, probably an average of about fifteen gallons of limed liquor made from pot-ale alone (equivalent to 1·5 gallons of pot-ale) could be successfully treated per cube yard throughout the distilling season. The final contact effluent at Mortlach in June, 1908, required but little further oxidation to render it of excellent quality. This could, we think, be best done by the method followed by Dr. Cowie in his experiments of some years ago, viz., by a further treatment of the final contact effluent through a percolating filter. Here, a rapid rate of percolation, say, up to 500 gallons per cube yard per twenty-four hours, would probably be found quite sufficient.

With a mixture of distillery liquors of greater organic strength, the volume would be smaller. Limed steep water is more difficult to purify upon contact beds than limed liquor made from pot-ale, the same figure for "oxygen absorbed" from permanganate being assumed for both. Limed steep water that is to be treated upon contact beds ought not to have a figure for "oxygen absorbed" in four hours much above 25.

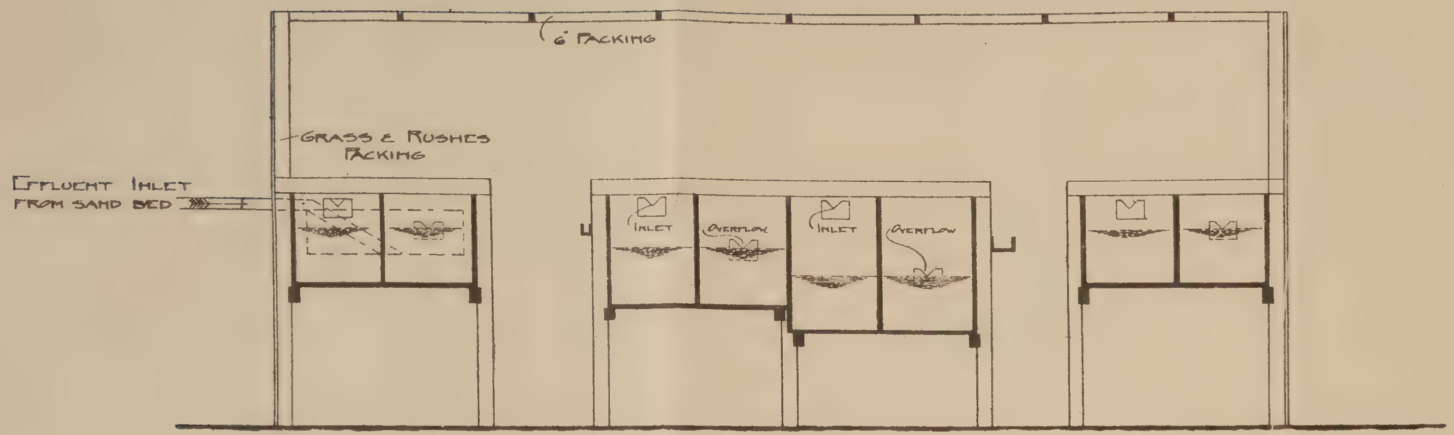
6. Since the proportion of carbonaceous to nitrogenous matter in distillery waste liquors is so much greater than in sewage liquors, the calculation of the percentage purification of effluents, on the basis of "oxygen absorbed" from permanganate alone, might be expected to approximate much more nearly to the actual truth in the case of filter effluents from distillery waste. The figures given in the two last columns of Tables B and C bear this out.

George McGowan.

Ealing, *January*, 1909.

ROYAL COMMISSION ON SEWAGE DISPOSAL DISTILLERY WASTE LIQUIDS

HATCHERY AND ARRANGEMENTS IN THE SALMON EXPERIMENTS



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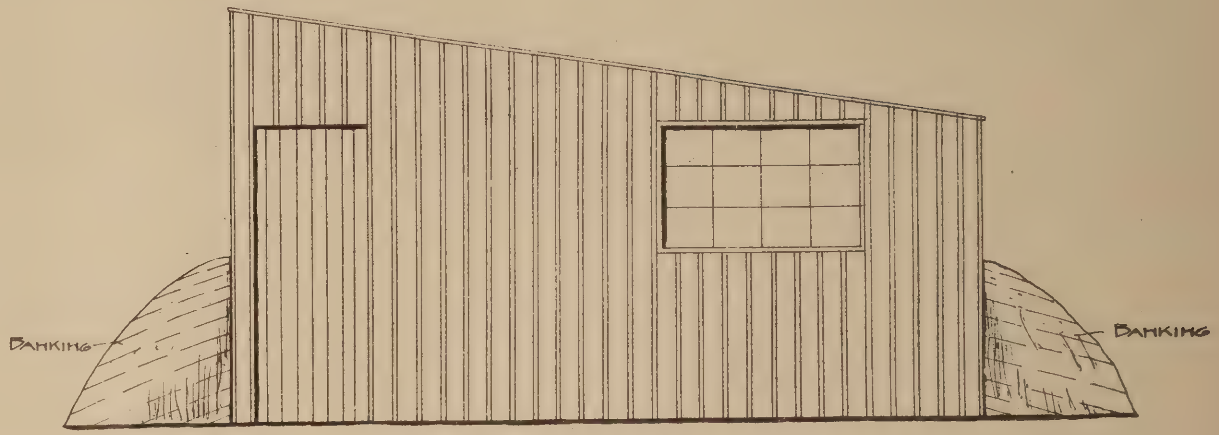

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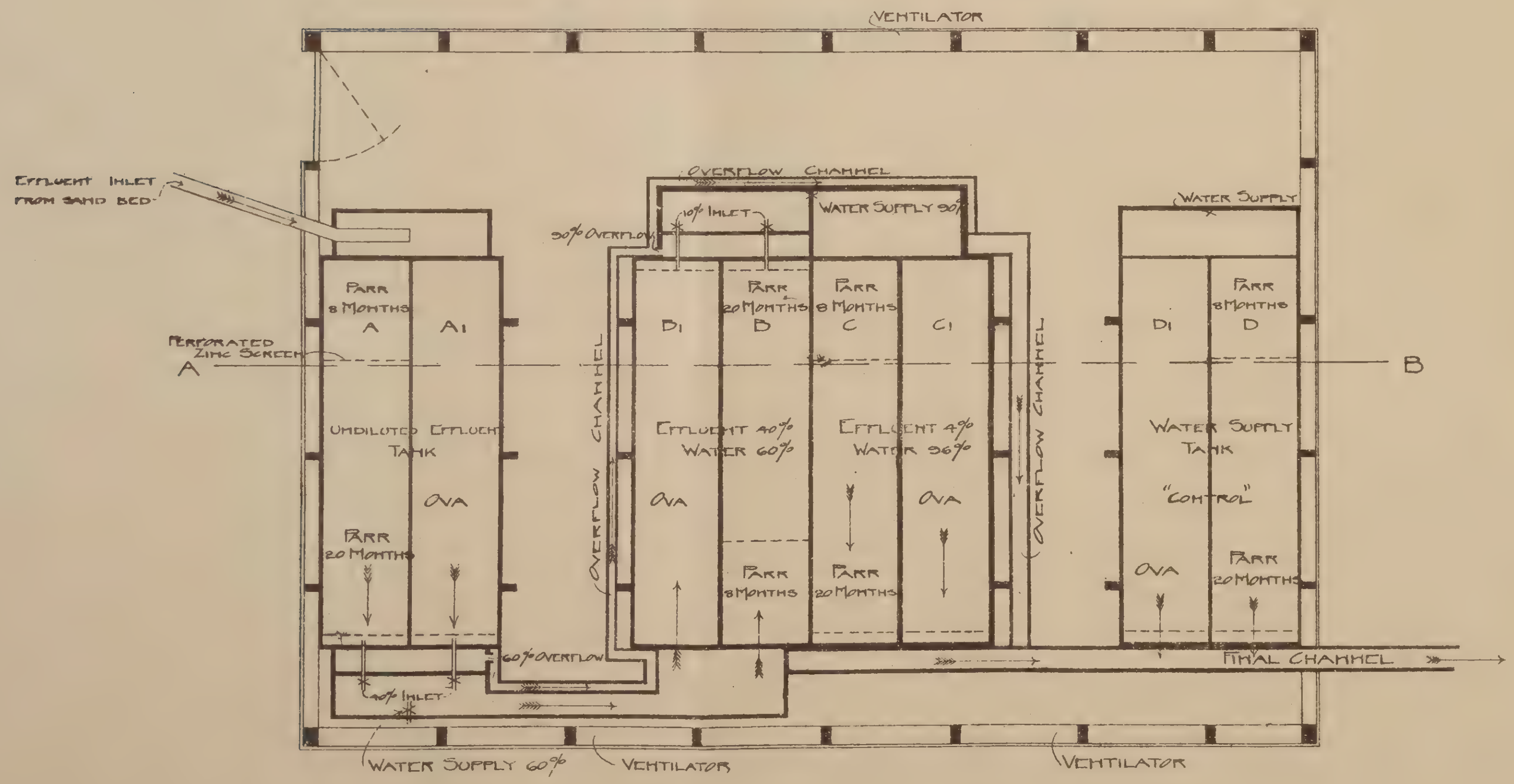

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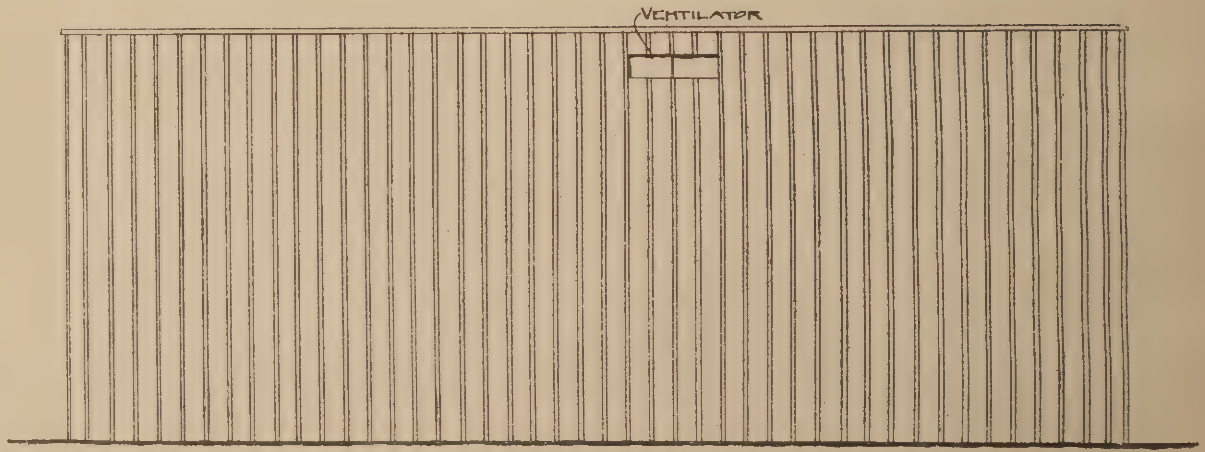

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Charles C. Doig
Architect
Elgin

APPENDIX IV.

REPORT BY Mr. W. L. CALDERWOOD AND Mr. ROBERT D. LITTLEFIELD.

Coleburn,
Longmorn,
Morayshire.
December, 1908.

To The Rt. Hon. the Earl of Iddesleigh, Chairman of the Royal Commission on Sewage Disposal.

My Lord,—We have the honour to submit a report on direct experiments carried out at Coleburn Distillery in order to test the effects, upon salmon ova and salmon fry, of the effluent obtained by the Commission's method of bacterial filtration of distillery bye-products.

We are, My Lord,
Your obedient Servants,

(signed) W. L. Calderwood,
Robert D. Littlefield.

In the report to the Royal Commission on Sewage Disposal by one of us dated December, 1908,* ths process experimented upon by the Commission at the Coleburn distillery for purifying the exceedingly polluting waste liquors, bye products in the manufacture of whisky, is fully explained. The result of many analyses of the effluent, a study of the class and amount of growths it would promote, and some minor experiments made with trout in a small burn into which the effluent was discharged, seemed to indicate that the effluent from this experimental plant would be harmless to fish life were it discharged into a fishing stream. The Commissioners were of opinion, however, that it was desirable definitely to ascertain whether an effluent of this class would be harmless to the ova and fry of salmon, which in the early stages are recognised to be less hardy than trout, and accordingly the following investigations and experiments were made.

In producing the effluent upon which these experiments were based, one unimportant modification in the method of working the plant adopted during the previous year was made. In ordinary practice a purification plant would have one day's rest in seven; but the special circumstances of these experiments required a constant flow of effluent, so the approximate amount of crude distillery waste liquor—pot-ale—that ordinarily would have been disposed of in six days, was spread over seven. We particularly wish to point out that no extraordinary precautions were taken to produce an excessively high class effluent. It was obvious that if the results of these experiments were to be valuable, such an amount of purification that could always be obtained, provided the directions for working the plant as recommended in the report above referred to, were faithfully carried out, should be the basis of this investigation. In Table IV. figures of analysis of the effluent are given.

Care was taken to avoid temporary stoppage of the plant by frost or snow. When necessary the temperature of the liquor in the settling tanks was kept 2 or 3 degrees above freezing point by means of a hot-water circulation system similar to that used in greenhouses. And the percolating filter, being in an exposed position, was roofed over with wood, thus keeping off snow and preventing the holes in the distributing arms from freezing up. During the whole period of the experiment the flow of effluent has been continuous.

A hatchery was built near the purification plant, and our best thanks are due to Messrs. John Robertson & Son, Ltd., for the facilities they have kindly given us for carrying out the work. A plan of the hatchery is inserted.

The structure was of wood roofed with felt. To keep out frost, the inside was lined with dried rushes and grass packed together, 4 inches thick, and a 6-inch packing of broom-tops lined the inside of the roof. The outside of the shed as far as possible was protected with a bank of earth to the height of the fish tanks inside the hatchery. Suitable ventilators and windows were provided.

Inside the hatchery all the tanks were made of seasoned white-wood, joints tongued and grooved, and no paint or putty used. All inside surfaces of the tanks and of the water and effluent channels were charred. It was decided to make four distinct and simultaneous experiments with (*a*) salmon ova, (*b*) fry eight months old, and (*c*) parr twenty months old.

Four pairs of tanks were arranged and labelled respectively A and A_1, B and B_1, C and C_1, D and D_1.

In the first pair (A and A_1) the undiluted effluent, deprived of its suspended solids by straining through shallow sand beds after leaving the percolating filter, was introduced. Since no natural stream can consist entirely of the effluent resulting from the purification of distillery waste liquids, this test must be regarded as quite exceptionally severe.

In the second pair of tanks (B and B_1) the liquid consisted of 40 per cent. of effluent and 60 per cent. of water. Such a mixture as this could conceivably occur close to the outfall of a purification plant in a burn.

In the third pair of tanks (C and C_1) we used a mixture of 4 per cent. effluent and 96 per cent. of water. This we consider would be the maximum proportion of effluent that in practice would occur in a fishing stream of any importance.

In the fourth pair of tanks (D and D_1) we used the water supply alone as a control experiment. In connection with this experiment we ought to say that the supply consisted chiefly of surface water draining from neighbouring hills, mostly uncultivated, collected in a dam, with a proportion, probably 20 per cent., of spring water. On analysis (*see* Table III) the water did not equal in purity that found in many Highland burns, and certainly would not have been considered satisfactory as a permanent supply to a hatchery.

As the total volume of effluent from the continuous filter amounted to 4,000 gallons per twenty-four hours, *i.e.*, 2,000 gallons per twenty-four hours for each of the first pair of tanks from which the remaining tanks, except those of the control experiment, had to be supplied, this factor determined the rate of flow. To obtain accurate comparison a similar flow of water was maintained in the control experiment.

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* *See* Appendix II.

The proportion of effluent to be delivered into tanks B and B_1, C and C_1, was obtained by a simple arrangement of taps and bye-passes, *vide* plan. The inlet and outlet of each tank was over a V notch—the inlet V being 6 inches higher than the outlet. When filled to the overflow V notch each tank had a depth of 15 inches of liquid and a capacity of 140 gallons. Thus the liquid in each tank was changed about fourteen times in twenty-four hours.

As the proposed experiments came within the meaning of the Vivisection Act, 39 and 40 Vic., cap. 77, it was necessary for the place to be registered and to obtain a licence and Certificate A from the Home Secretary. These formalities were complied with.

By the courtesy of His Grace the Duke of Richmond and Gordon we were provided with fifty salmon fry aged 20 months, fifty parr aged 8 months, and a suitable supply of ova.

The fish which supplied the ova were caught near Tugnet, Fochabers-on-Spey, on December 12th, 1907, at 8 a.m. and the fry collected about the same time from the Duke's rearing ponds. About 30,000 ova—the mingled spawn of six fish—were received. The consignment was despatched by train to Elgin and conveyed to Coleburn in the usual fish tanks and egg-carriers. By noon the same day all the young fish were safely transferred into the water-tank D. Of the ova sent we used about 12,000, the remainder being taken back to the Duke's private hatchery at Fochabers.

Into one of each pair of tanks ten of each age of the fry were put. The bottom of the tanks in these cases was covered with gravel which had been previously sterilised by boiling. The tanks containing the young fish were A, B, C and D. Into the other of each pair was put a grille carrying about 3,000 eggs, supported on bricks 9 inches from the bottom—6 inches below the surface. These tanks were covered over with sacking during the hatching period. The tanks containing the ova were A_1, B_1, C_1 and D_1. The following morning the fish were all vigorous and the few eggs which had been damaged by handling, or in transit, were removed.

A daily record has been kept of the maximum and minimum air temperatures recorded in the hatchery, and of the liquid in each tank (*see* Table I.). Generally twice a week the amount of dissolved oxygen in each pair of tanks has been measured and similarly the amount of this oxygen consumed on incubation for three days at 65° F. Also twice a week a full analysis of the effluent has been made and the amount of purification effected by the filter—as measured by the oxygen absorbed from acid permanganate in four hours at 80° F.—was recorded generally on alternate days (*see* Table V.).

The grilles were inspected daily for dead eggs and these were removed and the number recorded.

During the first month from time to time one or two of the smallest of the younger fry were found dead in the tanks. It was obvious they had been killed by the older and larger fish. To prevent this and whilst there were still some of the young fry living in each tank, the two ages were separated by a perforated zinc screen. At the same time a few more small fry were obtained from Tugnet. Since this time no dead fish have been found in tanks A, B, and C. Five small ones have been found dead in D—the pure water tank. During the whole of the period there have been no deaths amongst the older parr.

The fish have been fed generally twice a week. Various foods have been used but chiefly boiled and minced beef, dried shrimps, fish meal and broken biscuit. Any one of these foods seemed equally acceptable to the fish. Any uneaten food was removed from time to time to prevent moulding. During the whole period both sizes of fishes have been uniformly vigorous and have fed well. The development in both ages of fish in all the tanks was even and well marked. Undoubtedly the fish of both sizes in tanks A and B throve well and we think showed the greatest general development. (*Cf.* Tables of sizes in the Addendum). We think there is no doubt that the modicum of nutrient organic matter contained in the effluent promoted the growth of minute forms of fish food and that the fish found this agreeable. That percolating filters treating oxidisable liquids form a suitable breeding place for swarms of flies is a recognised fact and we know that the effluent from the filter in this case brought with it some small worms despite the straining beds and that these worms were devoured by the fry.

Figures of chemical analysis of typical samples of the effluent are given in Table IV.

In Table V. it will be observed that the effluent was always well aerated as it entered the hatchery. We wish to call particular attention to the fact that the organic matter contained in it was capable of only a relatively slow absorption of dissolved oxygen.

Generally on incubating a sample of the effluent for three days at 65°F. considerably less than half the dissolved oxygen was consumed. This is distinctly less than the rate at which a stream of it would be capable of taking up oxygen from the air.

Hatching.—It is the experience of those who undertake fish hatching operations that the period of incubation is much influenced by the temperature of the water, a relatively high temperature accelerating, and a low temperature retarding, the period.

In the four pairs of tanks at Coleburn considerable differences of temperature were experienced at times, owing to the open nature of the percolating filter rapidly reducing the temperature of the effluent passing through it during cold frosty weather, while the temperature of the water supply, mixed to a greater and less extent in tanks C and B and used entirely in the control tanks D, followed the air temperature slowly in the normal manner. The result of this was that the tanks in which the effluent was used alone, or in which it was used in large proportion, maintained a lower temperature than those in which water bulked most largely.

The highest mean temperature being found in tank D_1, we expected that hatching would first take place here; and this was realised. The first alevins appeared on the 112th day and the majority hatched out between the 114th and 116th days. It has already been noted that a certain number of eggs which had been brought from Tugnet were not required, and were carried back by the attendant to the Fochabers hatchery. The majority of those hatched out, we are informed, on the 112th and 113th days.

Tank C_1, which had only 4 per cent. of effluent and was therefore most nearly approximated in temperature to the control experiment tank, was next in order. Alevins commenced to appear in this tank on the 113th day, and the bulk hatched out on the 116th day.

In tank B_1, hatching was slightly slower but equally successful; it began on the 118th day, and active hatching occurred on the 122nd day and lasted till the 125th day. This tank, it will be recollected, contained 40 per cent. of effluent. The mean temperature for twenty weeks was only one degree higher than the mean of the effluent for the same period.

The altogether exceptional test in tank A_1 alone remained and we should not have been surprised if, under such unnatural conditions, the hatching of this grille of ova had turned out only a partial success. Hatching had only just begun on the 121st day when a spell of very cold weather set in. During sixteen days following the first hatch only fifteen alevins appeared. Although this period occurred in the middle of March the mean tank temperature during these sixteen days was only 36° F. On the 137th day, however, hatching became general and vigorous, and in three days the whole of the grille was cleared.

A most successful issue was therefore obtained even in this tank of undiluted effluent coming directly from the filter.

It appears to us that this result requires little comment. The test was more severe than could possibly occur in nature in the neighbourhood of any distillery at which the Commission's method of treatment might be adopted, and yet the ova were not injured in any way. In the event of an effluent of the nature here experimented with being run into any spawning streams, the retarding effect of the low temperature would not be felt, and we have no hesitation in saying these experiments show that no deleterious influence of any kind would result from the treated diluted potale, spent-lees, and steep water. With regard to the long period of incubation, it may further be said that in experiments made to test the effect upon ova of water kept near the freezing point under good hatching conditions, hatching resulted in about 130 to 135 days, so that, even apart altogether from the question of the effluent, the result harmonises with hatching in pure water at a low temperature.

Glancing now at the loss of ova during incubation, we are also able to show a condition which would be regarded as quite satisfactory in a hatchery using spring water alone. Each grille was estimated to hold about 3,000 ova. The actual number of dead eggs removed from each was as follows :—

From A_1 - - - -	159.
„ B_1 - - - -	161.
„ C_1 - - - -	132.
„ D_1 - - - -	241.

Growths occurring on the various Tanks.—We anticipated that during the progress of our experiments we should be able to study the nature of the growths that would occur in the mixture in the various tanks. We may say at once that the amount of the growths in the tanks was very small. In quantity there was very little to choose between the four experiments, probably the amount in tanks A and B rather exceeded the quantity in C and D tanks, though in C in one part the growths were greater than any other tank. Generally the length of the growths did not exceed one inch with the bulk not longer than quarter of an inch. All the growths were white or grey, no green algæ were observed in the hatchery, probably by reason of the absence of sunlight. In channels outside the hatchery carrying the same liquids, green algæ were abundant.

We observed that after the first five or six weeks the growths in the tanks did not increase in size or amount. In course of time the growths became coated with fine suspended solids, settling on them from the liquid in which they were growing Frequently this was sufficient to cause them to break away. We think it is highly probable that the growths were roughly proportionate to the amount of nutrient matter available and that a stage of equilibrium results and the growths do not increase in size. Three samples were collected and sent to the Director of Kew Gardens for identification.—1. From the water supply experiment ; 2. From tank C ; 3. From tank A.

Sample I.—The growths were taken from the box delivering the water supply to tanks D and D_1. Similar growths occurred in the tanks themselves. They were grey white in colour. They were indentified as chiefly *Fusoma parasiticum Tubœf* together with *Apodya lactea*. *Fusoma parasiticum* is abundant in the vicinity of the hatchery. A practically pure culture of it grows on the top of the percolating filter so luxuriantly that at intervals it causes clogging and has to be removed. It is a very common humus flora, and as its name complies, is a parasite which is said to attack and spoil young coniferous trees.

Apodya lactea is commonly regarded as "sewage fungus" and at first blush it would seem somewhat unpleasant that our water supply to the hatchery should promote such a growth. We have already noted the source of the supply. It seems evident that minute growths of this fungus are inevitable when there is a modicum of nutrient organic matter in streams where the spores of the fungus are abundant.

Sample II. was taken from the mixing tank supplying tanks C and C_1. This particular sample was the most luxuriant sent, some of it was growing on a little oat-meal that had been used six weeks previously to stop a leak in the tank. *Apodya lactea* was present in greatest quantity, also considerable percentages of *Achlya oblongata* and *Aphanomyces stellatus*. It is noticeable that *Fusoma parasiticum* was not found in this sample.

Sample III.—This was the mixed growths occurring in tank A. It consisted chiefly of *Apodya lactea*, *Achlya oblongata*, *Aphnaomyces stellatus*, *Saprolegnia hypogyna*, *Pythium proliferum.*

The following remarks were made by Mr. G. Massee, who wrote the report for the Director of Kew Gardens :—"In Samples II. and III. the composition of the water has proved detrimental to the growth of green algæ of which not a trace has been found. On the other hand members of the *Saprolygneaceæ* find such conditions congenial and are represented by five species in addition to various sterile forms that cannot be determined." We are inclined to think that the absence of sunlight must have had a marked effect on the character of these growths—for in Sample I. the growths occurred in the pure water supply tank. Again, outside the hatchery in open channels, green algæ were abundant both before and after passing through the hatchery. In addition to the saprophytic fungi in A noted above, we also identified *Saprolegnia ferox*, the "salmon disease fungus," which grew rapidly on uneaten food, dead eggs or dead fish left in the tank for two or three days. This fungus is not the cause of salmon disease, but occurs after the action of a bacillus—*bacillus salmonis pestis*. It grows very rapidly on a wounded fish even though it is living.* The fungus throve equally well in all four tank experiments if dead animal matter were left in them. We have not found it growing on the living fish in these experiments.

The presence of these growths apparently had no effect whatever on the fish—indeed we think it could hardly be otherwise, for in nature a fish is frequently in contact with growths of far greater amount and which we have reason to believe under microscopic examination would reveal the presence of some at least of those found in our experiments.

We have made the following experiments on living fish with regard to the effect the unpurified liquor would have on them :—

I. A strong parr died in two minutes in undiluted pot-ale.

II. A strong parr one year old placed in the "liquor" as made up for treatment on the percolating filter showed distress in four minutes and was dead in forty minutes.

III. Three similar parr were placed in the limed liquor as in II. in separate beakers :—

(*a*) The fish was given two and a half minutes in the liquid, and then, in obvious distress, was placed in the pure water tank. This fish died next day.

(*b*) The fish was four minutes in the limed liquor and then placed in the water tank. It was found dead the next morning.

(*c*) A fish was kept for thirty minutes in a somewhat weaker liquor, then transferred to pure water tank. In this case the fish lived for three days but it was never at all vigorous.

IV. A parr was kept for ten minutes in a freshly-made mixture of one part of pot-ale and twelve parts of water, and then transferred to the pure water tank. It was found dead in the tank thirty-six hours later.

We consider these experiments amply demonstrate the harmful effect unpurified distillery waste liquors have on fish life.

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* "The cause of salmon disease," by J. Hume Patterson. 1903.

CONCLUSIONS.

In summing up the conclusions to be drawn from our experiments we consider that we have proved that the effluent obtained by the method of bacterial purification of distillery waste liquids, as adopted by the Royal Commission on Sewage Disposal at Coleburn and carried out in accordance with the Commission's directions, is absolutely harmless to the ova and young of salmon, and therefore, of course, to hardier fish, *e.g.*, trout. It has been shown that not only did the ova hatch out well and the alevins thrive in dilutions of the effluent, but also in the effluent undiluted. The parr of both ages in all three experiments did excellently. They were always vigorous and fed well and compared most favourably with those in the control experiment.

The hatchery experiment was concluded on June 16th, 1908, thus for six months the conditions in the various tanks had been kept constant. At this time the fry were from eight to ten weeks old and all in good condition. Before dispersing the fish the effluent from the percolating filter was cut off from the hatchery and water from the dam was allowed to run through all the tanks for three weeks. This change had no apparent effect on the fry or larger fish. During the last fortnight—June 20th to July 3rd—the weather was exceedingly hot and dry and the temperature of the water supply frequently reached 70°–72° F. and as a consequence the mortality amongst the fry was heavy—from 100 to 150 dying per day. The larger fish were not inconvenienced.

On July 2nd and 3rd the tanks were emptied and the fish disposed of as follows :—

The fry from tanks A, B, C, D, were sampled and specimens preserved—the remainder in A, B, C, were mixed together and about 3,000 were conveyed to His Grace the Duke of Richmond and Gordon's rearing ponds at Tugret in the hope that some of them would survive and reach the smolt stage.* About 250 were placed in a pond of spring water at Coleburn. All the fry in D were put into the Cole Burn. Of the larger fish—three parr and three smolts from each tank were preserved as specimens and the others put into the Cole Burn. This burn joins the River Lossie about five miles lower down.

Our investigation throws a new light on the question as to what is to be regarded as a polluting liquid in relation to a fishing stream. As far as the fish were concerned it was evident the effluent has no toxic properties and that no harm results from the lime used in the settling tanks prior to the distribution of the liquor on the percolating filter. Chemical analysis of the effluent shows the presence of organic matter in a considerately greater amount than is found in a typical Highland burn. But this organic matter is in a stable condition ; it is not readily oxidised and therefore does not deprive a stream into which it may be discharged of its dissolved oxygen. In fact the effluent itself as entering the hatchery was always well aerated. Organic matter and oxygen are both undeniably necessary to fish, and this effluent contained them.

As regards the quantity and nature of the growths occurring in the tanks, the conditions prevailing in the hatchery were the most perfect for their development, *i.e.* almost still water and absence of sunlight, yet in quantity they were very small and their effect was nil.

Finally we have no hesitation in stating that no harm whatever can result to fish and fish life in the discharge of an effluent of this character into a stream.

TABLE I.

Daily Temperature Records.

Date.	Hatchery Air Temperature.		A.	B.	C.	D.	Remarks.
1907.	Max. F°	Min.					
December 14th.	40	36	35·5	37	38	38	During first week of experiments the effluent was not very free from suspended solids. Quite bright after December 20th.
15 -	40	34	34	36	37·5	38	
16	39	34	36	36·5	37·5	38	
17 -	43	39	40·5	39	39·5	40	
18 -	46	41	40·5	41	41	41	
19 -	44	39	40	40	39·5	39	
20 -	42	38	37	39	40	40	
21 -	40	37	37	38	38·5	39	
22 -	42	39	39	39·5	39·5	40	
23 -	44	37	37	38	39	39	
24	44	35	35	38	38·5	39	
25 -	39	35	36	37	38·5	39	*Saprolegnia ferox* identified on a dead fish (small) in A.
26 -	39	35	34	36	37	37·5	
27 -	38	35	33	36	37	37	Very cold weather—much snow.
28 -	37	34	33	35·5	37	37	Two small dead fish in A.
29 -	38	32	32	35	36	37	
30 -	36	32	32	36	37	38·5	
31 -	36	32	32·5	36·5	36·5	38	Dead eggs removed to date, January 1st. —A_1 13, B_1 14, C_1 4, D_1 19.

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* NOTE.—In December 1908, we learned that the growth and development of the fry which we sent to Tugret had been quite normal.

TABLE I.—*continued.*

Daily Temperature Records—continued.

Date.	Hatchery Air Temperature.		A.	B.	C.	D.	Remarks.
	Max. F°	Min.					
1908.							
January 1 -	36	32	33	37	38·5	39	
2 -	37	32	32	36·5	38	38·5	
3 -	35	32·5	32·5	37	38·5	39	
4 -	36	34	33·5	37	38·5	39	Two small dead fish in D.
5 -	37	32	33	37	38	38·5	
6 -	38	34	37	37·5	39	39	
7 -	38	37	36·5	38	39	39	
8 -	40	36	33	37	38	38·5	
9 -	38	36	34	37·5	38	38·5	
10 -	38	35	33	38	38·5	39·5	
11 -	38	36	35	37·5	38·5	39	
12 -	39	38	34	37	38	38·5	
13 -	37	33	33·5	36·5	38	38	
14 -	40	36	36	38	38·5	38·5	Samples of growths sent to Kew.
15 -	38	36	35	37	39	39·5	
16 -	44	40	41	40	40	40	Dead eggs total to January 15. A_1, 39. B_1, 44. C_1, 21. D_1, 49.
17 -	48	40	43·5	41	41	41	Separated small and large parr by perforated zinc screen.
18 -	50	39	39	41	40	40	
19 -	48	36	34	37	38	39	
20 -	39	36	35	38	38·5	39	
21 -	41	35	35	37	38	38	
22 -	38	36	34	36	37·5	38·5	
23 -	44	34	37·5	37·5	38	38·5	Supply of small parr received and put into tanks.
24 -	44	34	34·5	38	38·5	39	
25 -	41	36	38	38	38	39	
26 -	42	38	36·5	38	39	39	
27 -	44	38	39	39	39	39	
28 -	44	36	35	37·5	38·5	38·5	Noted development of eyes in ova in B_1, C_1, D_1. None in A_1.
29 -	38	35	33·5	36·5	38	38	
30 -	38	34	34	36	38	38	
31 -	38	35	34	36	36·5	36·5	
February 1 -	38	33	32	35	36	36	Dead eggs total to February 1st. A_1, 63 ; B_1, 75 ; C_1, 49 ; D_1, 104.
2 -	38	33	33	35	38	38	
3 -	42	36	35	36·5	37·5	38	
4 -	39	35	33·5	36·5	38	38	Killed a small parr by accident in B.
5 -	42	36	38	37	38	38	
6 -	46	38	38	39	39	39	Water supply became clogged during night and ova in D_1 were just out of water at 7 a.m.
7 -	44	40	40	40	40	40	
8 -	47	42	41	41	41	41	
9 -	42	38	37	38	40	40	
10 -	42	38	39	39·5	40	40	
11 -	52	42	41	41	41	41	

TABLE I.—*continued.*

Daily Temperature Records—continued.

Date.	Hatchery Air Temperature. F°		A.	B.	C.	D.	Remarks.
	Max.	Min.					
1908. February 12 -	48	46	42	42	42	42	
13 -	46	38	38	40	40·5	40·5	
14 -	42	40	40	40	40·5	40·5	
15 -	49	37	37	39	39·5	39·5	
16 -	44	38	36	38	39	39	
17 -	40	34	35·5	37·5	38·5	38·5	Total eggs removed to February 16th. A_1, 79 ; B_1, 93 ; C_1, 54 ; D_1, 124.
18 -	44	38	38	39	40	40	
19 -	40	37	36	37·5	39	39	Small fish dead in D.
20 -	42	38	39	39·5	40	40	
21 -	48	43	43	42	42	42	
22 -	42	38	39	39	40	40	
23 -	42	36	33	37	38	39	
24 -	40	36	36	37	38	38	
25 -	42	37	37	38	39	39	
26 -	40	38	36	38	39	39	Very wintry weather to March 2nd; much snow.
27 -	40	36	33	37	38	39	
28 -	40	32	32	35·5	37	37	
29 -	38	34	33	36	38	38·5	
March 1 - -	40	35	33·5	35	36	36	
2 - -	41	36	33·5	35	36	36	Small fish dead in D.
3 - -	39	34	34	35	35·5	35·5	
4 - -	40	34	33·5	35	37	37	
5 - -	42	32	32	36	37·5	38	
6 - -	40	36	35	37	38	38	
7 - -	40	36	35	37	38	38·5	
8 - -	45	36	36	37	38	38·5	Water supply very muddy; heavy spate.
9 - -	40	38	37	37·5	37·5	37·5	
10 - -	40	38	38	38	38	38	
11 - -	44	36	37	37·5	38	38	Small fish dead in D.
12 - -	45	37	36·5	39	39	39	During week April 12th–19th there was considerable increase in growths and deposits on ova in A_1, B_1; less in C_1; ova in D_1 very dirty. Gently moved the eggs with a feather to remove this.
13 - -	42	37	36	37·5	39	39	
14 - -	44	37	36·5	38	39·5	40	
15 - -	46	35	36	38	39	40	
16 - -	43	35	34	37	39	39	
17 - -	46	36	37	38	39·5	40	
18 - -	48	38	37·5	38·5	39·5	40	
19 - -	41	35	33·5	37	39	39·5	
20 - -	46	36	33	37	39	39	Total eggs removed to March 20th : A_1, 84 ; B_1, 111 ; C_1, 67 ; D_1, 162.
21 - -	47	32	35	37	39	39	
22 - -	46	34	35	37	38·5	39	
23 - -	50	39	39	39	39·5	39·5	Small fish dead in D.
24 - -	54	40	41	41	41	41	

TABLE I.—*continued.*

Daily Temperature Records—continued.

Date.	Hatchery Air Temperature.		A.	B.	C.	D.	Remarks.
1908.	Max. F°	Min.					
March 25	46	40	38	39	40	40	
26	45	38	39	38	39	39	
27	47	38	39	39	39	39	
28	49	36	38	38·5	39	39·5	
29	54	47	45	42	41	41	
30	54	36	38	39	40	40	
31	48	39	38	39	40	40	
April 1	44	37	35	38	39	39·5	
2	57	40	41	41	41	41	Started hatching in D_1.
3	54	39	41·5	41·5	41·5	41·5	Started hatching in C_1.
4	44	40	39	40	40	40	
5	48	35	37	38·5	39	39	
6	48	37	40	40	40	40	
7	52	36	38	39	40	40·5	Small fish dead in D.
8	54	42	45	43	42	42	Hatching started in B_1.
9	48	36	45	43	43	43	Total eggs removed to April 10th : A_1, 96 ; B_1, 138 ; C_1, 103 ; D_1, 209.
10	52	38	43·5	40	41	41	
11	53	38	44	43·5	43	43	
12	50	38	43	40	41	41	Started hatching in A_1; very few out.
13	54	37	46	45	42	42	
14	54	36	42	40	41	41	
15	52	38	45	41·5	43	43	
16	51	38	45	41	42	42	
17	51	42	44·5	43	43	43	
18	52	39	41	42	43	45	Very wintry weather April 19th to 22nd.
19	48	38	38	40	41	41	Finished hatching in D_1 Total eggs removed 241. Finished hatching in B_1 and C_1. Total eggs removed : B_1, 161 ; C_1, 132.
20	44	38	41	39	41	41	
21	47	36	37	39	41	41	
22	40	36	38	38·5	40	40	
23	40	36	34	38·5	41	41	6 degrees of frost at night.
24	42	32	34·5	38·5	40	40	10 degrees of frost at night.
25	44	38	39	39	41	41	
26	54	33	35	38	40	40	Hatching out very rapidly in A_1 on 26, 27 28.
27	46	40	40	39	41	41	
28	51	38	42	42	42	42	
29	53	38	43	43	43	43	Finished hatching in A_1. Total number of eggs removed=159.
30	56	40	47	45	44	44	
May 1	54	46	51	45	45	45	
2							
3							
4							Following alevins have been removed dead from tanks to May 2nd. A B C D 21* 7 64† 29.

Note.—Many alevins have escaped into adjacent tank of pair—the common bottom having sagged. Most in D_1, to D probably 200, and same in B_1 to B. They have been killed by the larger fish. Leaks have been stopped.

* Twelve of these hatched before April 26th and being weakly succumbed to severe weather April 23rd–24th.

† About half of these were killed by accidental breaking of grille by Mr. Robertson's dog.

TABLE II.

Hatching-out Dates.

Tank.	First alevins appeared on the	Bulk hatched out between the
A_1.	121st day.	137th and 139th day.
B_1.	118th „	122nd – 125th „
C_1.	113th „	115th – 116th „
D_1.	112th „	114th – 116th „

Note in A_1.—Between 121st and 137th days not more than 15 alevins appeared—the majority of which died in the bitter weather experienced about the 131st day. When general hatching commenced it was rapid, and alevins were strong.

TABLE III.

Analysis of Water in Tanks D and D_1. Parts per *100,000.*

—	January 7th.	February 15th.	March 9th.	
			(*a*)	(*b*)
Ammoniacal Nitrogen - - - -	0·0034	0·0034	0·0038	0·0034
Albuminoid Nitrogen - - - -	0·0072	0·0057	0·0201	0·0135
Oxygen absorbed in four hours - - -	0·256	0·083	0·454	0·365
Dissolved oxygen - - - -	0.980	—	–	—
Nitric Nitrogen - - - - - -	0·05	0·104	0·08	—
Chlorine - - - - - -	2·42	2·19	—	—

Note March 9th—Water supply was turbid, heavy spate.

(*a*) Water before filtration. (*b*) Paper filtered.

TABLE IV.

Some Typical Analyses of the Effluen .

Parts per 100,000.

All samples were analysed without filtration, *i.e.*, in the condition they were entering the hatchery.

Dates. (1907–8.) =	Dec. 23.	Jan. 6.	Jan. 24.	Jan. 29.	Feb. 7.	Feb. 17.	March 2.	March 18.	March 25.	April 2.	April 13.	April 23.	April 28.	May 13.	May 20.
Ammoniacal Nitrogen - -	0·01	0·04	0·02	0·02	0·02	0·012	0·02	0·06	0·04	0·04	0·06	0·04	0·04	0·04	0·02
Albuminoid Nitrogen - -	0·12	0·18	0·10	0·11	0·14	0·082	0·15	0·18	0·16	0·14	0·16	0·16	0·18	0·16	0·14
Oxygen absorbed in four hours	1·84	1·92	1·20	1·68	1·92	1·44	2·00	1·84	1·92	1·68	1·68	1·52	2·00	1·68	1·44
Nitrous and Nitric Nitrogen	0·40	0·30	0·49	0·404	0·40	0·32	0·41	0·40	0·40	0·50	0·60	0·50	0·40	0·60	0·60
*Alkalinity (as CaO.)- -	12·48	14·4	14·40	14·4	14·7	15·3	12·48	11·52	12·96	10·08	12·48	11·52	11·04	11·52	14·4
Dissolved Oxygen - -	0·81	3·80	0·87	0·97	0·72	0·80	—	0·58	0·62	0·66	0·68	0·72	0·72	0·74	0·74

(Signed) R. D. Littlefield.

Note :—None of the samples of effluent putrified on incubation for five days at 27° C. (80° F.).

* The alkalinity was entirely due to Carbonate of lime.

TABLE V.

Table showing (*a*) Average (weekly) temperature of the tank liquids, (*b*) The amount of dissolved oxygen before and after three days' incubation at 60° F., (*c*) The amount of purification (as measured by the oxygen aborbed from acid permanganate in four hours at 80° F.) effected by the percolating filter. Temperatures are F°. Oxygen = number of ccs. per litre.

Date.	Tanks A.			Tanks B.			Tanks C.			Tanks D.			Parts per 100,000.		Percentage purification as measured by this test.
	Temp.	Dissolved Oxygen.	Ditto after incubation.	Temp.	Dissolved Oxygen.	Ditto after incubation.	Temp.	Dissolved Oxygen.	Ditto after incubation.	Temp.	Dissolved Oxygen.	Ditto after incubation.	O_2 absorbed in four hours. Untreated liquor.	O_2 absorbed in four hours. Effluent entering tank A.	
1st week ending Dec. 20th 1907	37·6	6·3	Traces	38·3	6·3	3·4	39·0	6·7	5·6	39·0	7·1	5·9	64·2	2·52	96·1
2nd " " " 27th "	36·0	6·3	2·5	37·3	6·3	5·5	38·3	6·4	5·7	38·6	7·2	6·3	63·9	1·64	97·5
3rd " " Jan. 3rd 1908	32·4	6·3	0·6	36·2	6·3	4·7	37·3	6·4	5·6	38·1	6·9	6·8	67·5	1·86	97·3
4th " " " 10th "	34·2	6·4	2·6	37·2	6·1	5·5	38·4	6·2	5·9	38·9	6·1	6·1	73·9	1·74	97·7
5th " " " 17th "	36·9	6·1	5·0	38·1	6·5	6·2	39·0	6·2	6·2	39·2	6·9	6·3	80·4	1·41	98·3
6th " " " 24th "	35·5	7·0	6·4	37·8	7·3	6·5	38·3	7·1	6·5	38·9	6·7	6·3	82·4	1·34	98·4
7th " " " 31st "	35·7	6·8	5·6	37·2	7·2	5·9	38·1	7·3	6·8	38·3	7·3	6·5	78·0	1·48	98·1
8th " " Feb. 7th "	35·6	5·8	3·9	37·0	6·8	5·9	38·0	7·5	6·5	38·1	7·5	6·8	91·8	2·26	97·6
9th " " " 14th ,	39·7	5·4	3·9	40·2	7·0	6·2	40·7	7·9	6·7	40·7	7·9	7·1	90·0	1·50	98·4
10th " " " 21st "	37·8	5·3	2·5	39·0	5·9	5·2	39·7	6·7	6·6	39·7	6·8	6·6	71·9	1·20	98·4
11th " " " 28th "	35·1	4·9	3·5	37·3	6·8	6·2	38·4	7·5	7·3	38·7	8·0	7·7	70·0	1·66	97·7
12th " " March 6th "	33·5	6·3	2·1	35·5	7·5	6·1	37·0	8·6	6·4	37·0	8·6	6·8	80·5	2·00	97·6
13th " " " 13th "	36·5	6·4	1·0	37·6	6·9	2·9	38·2	7·8	6·1	38·3	7·8	6·2	85·9	2·72	96·9
14th " " " 20th "	36·3	4·1	3·0	37·6	7·4	6·2	39·2	7·3	6·2	39·5	7·8	6·8	71·2	1·86	97·4
15th " " " 27th "	38·0	4·3	3·5	38·6	6·4	5·2	39·4	8·7	6·3	39·4	8·7	6·4	74·4	1·75	97·7
16th " " April 3rd "	39·5	4·6	3·5	39·8	7·0	5·7	40·2	8·1	6·4	40·3	8·1	6·6	79·5	1·86	97·7
17th " " " 10th "	41·1	4·4	3·5	40·5	6·3	5·9	40·7	8·0	6·6	40·7	over 9	8·7	80·0	2·00	97·5
18th " " " 17th "	44·1	4·8	2·1	42·0	8·7	5·9	42·1	over 9	7·3	42·1	over 9	8·7	70·8	1·46	98·0
19th " " " 24th "	37·6	5·1	4·3	39·3	8·7	6·6	41·0	8·7	7·5	41·1	over 9	8·7	86·6	1·46	98·3
20th " " May 1st "	42·4	5·1	4·5	41·5	7·8	7·1	42·3	8·7	7·8	42·3	over 9	8·7	99·7	1·81	98·2
21st " " " 8th "	46·7	4·8	4·1	45·0	7·8	7·1	45·0	8·7	7·8	45·0	8·7	8·7	91·0	1·72	98·1
22nd " " " 15th "	53·0	5·2	3·5	47·7	7·7	—	47·3	—	—	47·3	—	—	90·4	1·72	98·1
23rd " " " 22nd "	52·8	5·2	—	50·6	7·3	—	48·6	—	—	48·6	—	—	89·6	1·44	98·4

ADDENDUM.

GROWTH OF PARR AND SMOLTS IN TANKS.

With reference to the statement that the young fish in the tanks containing the effluent in various strengths throve well, and that they showed greater growth than the fish kept in water, the following measurements, bearing out this statement, are of interest :—

——	Tank A. Undiluted Effluent.	Tank B. 40 per cent.	Tank C. 4 per cent.	Tank D. Water.
	C.m.	C.m.	C.m.	C.m.
Parr - - - - -	9	7·5	9·6	7·5, 5·3
Smolts - - - - -	13·5, 13·6, 16·7.	19·7, 12·9	11·8, 16·7, 17·0	11·4, 13·1, 13·2

These measurements were taken towards the close of the experiment—in May, 1908. The parr were then thirteen months old, and the smolts twenty-five months old ; the parr had spent half the natural period of life in fresh water previous to the first descent to the sea, the five last months of which were spent in the Coleburn hatchery, and the smolt had completed or practically completed that period and had assumed their silvery coat.

With hand feeding under artificial conditions a very marked variation in growth undoubtedly takes place, a small percentage of any one lot of fry growing to a size much above the average. So great has this discrepancy sometimes been at the Cunninghaugh Ponds, from which these young fish were brought, that specimens in the possession of one of us of fish one year and nine months old show extreme measurements of 10·3 c.m. and 28·8 c.m., or practically 4 inches and 8½ inches. Under natural or wild conditions these differences do not seem to occur. Large numbers of smolts have been examined and measured in the Tay, and no salmon smolt was noticed of a greater measurement than 19·0 c.m. while fish of 18·0 c.m. were extremely rare. The average size at time of migration was found to be 15·2 c.m. or about six inches.

With the conditions which obtained at Coleburn it is natural to expect that a somewhat exaggerated variation might exist as has been noticed amongst fish which are hand fed. In addition to the hand feeding also must be mentioned the apparent fact that the bacterial filter, owing no doubt to its open formation, seems the receptacle of numbers of flies of various sorts, and that the larvæ of these flies are carried off in the effluent. The larvæ were found in considerable numbers in the tanks, and although the extent to which they formed food for the young fish is not known, the presumption is that the feeding was increased owing to this source of supply.

At the Duke of Richmond's ponds at Cunninghaugh the average size of thirteen months old parr is fully 4½ inches, the size of twelve months old fish being 4¼ inches and of fourteen months old fish 5¼ inches. Taking 11·5 c.m. as representing the average growth at Cunninghaugh, the parr at Coleburn show about an inch less of growth on an average, approximating much more closely to the condition found in nature : and the fish in tank D are the smallest. The Cunninghaugh fish assume the silvery coat of smolts when from 6 to 7 inches in length, and the average length of twenty-six months old smolts, ready for the first migration, is given as 7 inches. The Coleburn twenty-five months old smolts are again smallest in the tank containing water, varying from 11·4 to 13·2 c.m. or 4½ to 5¼ inches. These are small fish as compared to the unconfined smolts found in rivers. The tanks contaning percentage of effluent show fish of better growth. In the 4 per cent. mixture 11·8 to 17·0 c.m., or 4¾ to 6¾ inches. In the 40 per per cent mixture, the largest fish of any occurred, viz., 19·7 cm. or 7¾ inches. The average for this tank is brought down, however, by 12·9 c.m. being the measurement of the other fish referred to. In the tank containing the undiluted effluent the fish vary from 13·5 to 16·7 c.m. or 5¼ to 6¾ inches, measurements which compare well with the measurements of smolts in nature. While too much stress need not be placed upon the measurements of so small a number of fish as compared with fish either in the wild state or reared in large ponds, it is none the less valuable to note that amongst fish kept in four tanks of precisely similar dimensions under the same roof, those living in the effluent or in a mixture of effluent and water attained to a distinctly better size than did the fish kept in the local water supply alone.

APPENDIX V.

TABLES OF ANALYSES.

The following Tables of Analysis give most of the results obtained during the Commission's experiments on the purification of distillery waste liquors. In order to avoid unnecessary detail, a number of the figures have been averaged, one or two separate typical analyses being added for explanatory purposes. The figures of the other Tables it has either been impossible or undesirable to average.

The analyses have been made by the methods described in the Fourth Report of the Commission, Vol. IV., Part V. The following particulars may, however, just be mentioned :—

1. Glass-distilled water was used in the determination of the Ammonias ;
2. The Permanganate employed in the "Oxygen absorbed" test was the "strong" solution, *i.e.* $\frac{N}{8}$ Permanganate ;
3. The determinations of dissolved Oxygen were done by Winkler's (Manganese) method, as modified by Rideal and Stewart ;
4. The incubation temperature for rate of absorption of dissolved Oxygen was 18° C. (65° F.), except in the case of Tables 8 and 9, when the temperature was 27° C. (80° F.)

These analyses and the other chemical work connected with the inquiry were partly done by Mr. R. D. Littlefield at Coleburn and partly in the laboratory at Ealing. The work at Ealing has been mainly done by Mr. A. C. Carter, F.I.C., Mr. A. F. Girvan, B.Sc., and Mr. W. G. Winterson, B.Sc. ; and I should like to be allowed to draw the attention of the Commission to the able and thorough manner in which they have carried it out.

George McGowan.

Ealing.

January, 1909.

TABLES.

1. Analysis of typical samples of Pot-Ale, Steep Water and Spent Lees.
2. *Coleburn.*—Figures of analysis of Effluents obtained during the Maturing of the Filter (1906).
3. *Coleburn.*—Typical analyses of Limed Liquor and of Effluent during the period of Maturing the Filter (1906).
4. *Coleburn.*—Average figures of analysis for Filter treating Limed Steep Water alone (1906).
5. *Coleburn.*—Average figures of short analyses for Filter treating Limed Liquor made from the whole of the Distillery Waste Liquids (1906–7)
6. *Coleburn.*—Figures of the more detailed analyses for Filter treating Limed Liquor made from the whole of the Distillery Waste Liquids (1907).
7. *Coleburn.*—Average figures of analysis of Limed Liquor and Effluent during the Salmon Experiments (1907–8).
8. *Coleburn.*—Average percentage purification, as measured by the Reduction in "Oxygen absorbed" from $\frac{N}{8}$ Permanganate, during the Salmon Experiments (1907–8).
9. *Coleburn.*—Oxygen in solution in the Coleburn Effluent during the period of the Salmon Experiments (1907–8).
10. *Coleburn.*—Average figures of analysis for Filter treating Limed Steep Water alone (1908).
11. *Coleburn.*—Analyses of Growths from Effluent Channels, etc.
12. *Coleburn.*—Analyses of Air-dried Precipitation Sludge.
13. *Coleburn.*—Experiment on the addition of Nitrate of Soda to the Limed Liquor (1908).
14. *Coleburn.*—Experiment on the addition of Sulphate of Ammonia to the Limed Liquor (1908).
15. *Mortlach.*—Average figures of analysis of Limed Liquor made from Pot-Ale and of Effluents from the 5th and 6th Contact Beds (1907–8)
16. *Mortlach.*—Treatment of diluted Pot-Ale on a Percolating Filter.
17. *Mortlach.*—Detailed figures of analysis of Limed Liquor made from Pot-Ale and of Effluent from 6th Contact Bed (1908).
18. *Mortlach.*—Figures of analysis of Limed Liquor made from Steep Water and of Effluents from 3rd and 6th Contact Beds (1908).
19. *Wandsworth.*—Samples of Waste Liquors from a Grain Distillery.

TABLE I. ANALYSIS OF TYPICAL SAMPLES OF POT-ALE, STEEP WATER, AND SPENT LEES.

Parts per 100,000.

Description of Sample.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (by smell).	Dissolved Oxygen taken up in 24 hours.	Dilution.	Dissolved Oxygen taken up in 48 hours.	Dilution.	Dissolved Oxygen taken up in 5 days.	Dilution.	Dissolved Oxygen taken up in 7 & 6 days.	Dilution.	Total Solids.	Solids in Suspension.	Volatile Matter in Suspended Solids.	Centrifuge Solids.	Ratio of Suspended Solids to Centrifuge Solids.	Remarks.
1. From Coleburn Distillery.																							
Pot Ale.											Vols. of tap water		Vols. of tap water		Vols. of tap water.		Vols. of tap water						
January 21st, 1909	4·90	96·0	202·7	—	—	207·6	80·3	1657·0	—	—	—	825	2,499	2,500	4,999	—	—	3539·0	701·5	678·0	8,040	1 : 11·5	This was a sample of pot-ale of average quality, as it comes from the still.
Strong Steep Liquor.																							
October 30th, 1908	0·90	5·34	10·26	—	—	11·16	12·28	117·65	—	—	—	167·1	299	—	—	211·0 (7 days)	999	—	13·7	12·3	43·3	1 : 3·2	
Second Steep Liquor.																							
October 31st, 1908	0·60	2·29	3·89	—	..	4·49	5·01	70·76	—	—	—	96·5	149	—	—	145·5 (7 days)	499	—	5·3	5·2	14·2	1 : 2·7	
Mixed Steep Liquor.																							
November 7th, 1908	1·44	2·92	4·53	—	—	6·07	7·11	65·24	—	—	—	115·5	149	133·0 (4 days)	249	159·6 (6 days)	399	—	—	—	—	—	
2. From Dailuaine Distillery.																							
Spent Lees.																							
April 21st, 1904 -	0·11	0·19 †	0·21	0·00	0·00	0·34	3·71	53·60	Strong brewery smell.	0·11	2	—	—	—	—	—	—	—	—	—	—	—	This is a strong sample. It possessed a strong yeasty and alcoholic smell and was acid to litmus, even after boiling.
3. From Mortlach Distillery.																							
Spent Lees.															Vols. of tap water								
Nov. 13th, 1908 (*a*)	0·04	0·05	0·16	0·00	0·00	0·20	1·41	16·18	—	—	—	—	—	1·75	9	—	—	17·9	1·1	0·4	1·8	1 : 1·6	Both of these samples are weak ones. They possessed a strong and pungent alcoholic smell. Both were acid to litmus after boiling.
„ 23rd, „ (*b*)	0·04	0·06	0·08	0·00	0·00	0·12	2·36	17·57	Strong yeasty, alcoholic smell.	—	—	—	—	4·85	9	—	—	24·4	3·2	1·8	2·2	1 : 0·7	
(*a*) 200 c.c. of this sample were distilled, 100 c.c. of distillate being collected. The residue from the distillation was made up to 200 c.c.																							
Distillate - - - - -								$\frac{16{\cdot}54^{*}}{2}$	Specific Gravity at 17·7° C. = 0·998.														
Residue - - - - -								6·88	-	-	-	-	-	0·63	9								

* The "Oxygen absorbed" in 4 hours, on the 100 c.c. distillate, was 16·54 per 100,000.

† Distilled water from a continuous-feed copper still was used in this analysis.

COLEBURN.

TABLE 2.—FIGURES OF ANALYSIS of Effluents obtained during the Maturing of the Filter—June to September, 1906.

Parts per 100,000.

Date.	Quantity of Pot-ale treated per cube yard per 24 hours.	Limed Liquor.			Effluent.					Remarks.
		Ammoniacal Nitrogen.	Albuminoid Nitrogen.	"Oxygen absorbed" in 4 hours.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	"Oxygen absorbed" in 4 hours.	Nitric Nitrogen.	Alkalinity as CaO.	
1906. June 20th - -	0·15 gallon.	—	—	114·8	0·05	0·13	3·10	0·16	—	Limed liquor 1 in 10.
„ 20th - -	—	1·71	7·76	109·96	0·73	0·24	1·40	0·06	—	„ „
„ 25th - -	0·17 „	0·78	6·42	114·8	0·31	0·21	4·03	0·08	3·06	„ „
„ 28th - -	—	—	—	90·22	0·24	0·24	1·77	0·14	—	—
„ 29th -	0·17 „	0·78	6·42	114·8	0·06	0·12	2·57	0·09	3·06	„ „
July 3rd - -	0·25 „	0·79	5·90	97·08	0·11	0·37	1·08	0·17	9·9	„ „
„ 4th - -	—	—	—	98·16	0·14	0·19	1·57	0·27	—	—
„ 9th - -	0·60 „	1·22	6·01	223·5	0·20	0·12	3·60	0·36	4·13	Limed liquor 1 in 5.
„ 16th - -	0·60 „	1·22	6·01	223·5	0·09	0·20	7·05	0·15	9·7	—
„ 18th - -	0·30 „	1·22	6·01	223·5	0·08	0·57	7·48	0·16	11·4	Filter rested 10 days.
„ 29th -	0·15 „	0·60	6·52	98·39	0·08	0·13	2·16	0·38	3·34	Limed liquor 1 in 10.
„ 30th - -	—	—	—	98·16	—	—	—	1·10	—	—
Aug. 3rd - -	0·25 „	0·60	6·52	98·39	—	—	1·80	1·03	6·84	„ „
„ 6th - -	0·35 „	—	—	91·70	0·04	0·23	0·72	1·20		„ „
„ 6th - -	—	—	—	94·20	—	—	1·32	0·72	—	„ „
„ 8th - -	—	—	—	89·25	0·02	0·16	1·56	1·27	—	—
„ 15th - -	—	—	—	94·82	—	—	1·40	0·82	—	—
„ 20th - -	—	—	—	102·74	—	—	1·41	0·15	—	—
„ 22nd- -	—	—	—	—	—	—	1·33	0·14	—	—
Sept. 1st - -	—	—	—	73·60	—	—	1·12	0·42	—	—
„ 2nd -	1·25 „	—	—	93·60	0·04	0·23	1·12	0·80	—	„ „
„ 5th - -	1·25 „	—	—	—	0·05	0·11	1·44	0·32	7·3	„ „
„ 8th - -	1·25 „	—	—	50·64	—	—	1·50	—	7·3	„ „
„ 10th - -	1·80 „	—	—	56·51	—	—	1·50	0·33	9·70	„ „
„ 13th - -	1·80 „	—	—	62·10	—	—	2·18	—	6·2	„ „
„ 14th - -	2·40 „	—	—	62·80	—	—	1·80	—	6·2	„ „
„ 15th - -	2·40 „	—	—	64·00	—	—	2·77	—	6·9	„ „
„ 17th - -	2·50 „	—	—	68·21	—	—	2·82	—	6·2	„ „
„ 19th - -	2·50 „	—	—	67·49	—	—	2·79	—	6·2	„ „
„ 20th - -	2·50 „	—	—	67·49	—	—	2·79	0·75	8·38	„ „

TABLE 3.—TYPICAL ANALYSIS of Limed Liquor and of Effluent during the period of Maturing the Filter. 1906.

Parts per 100,000.

Date—1906.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (smell).	Dissolved Oxygen taken up in 5 days.	Remarks.
Limed Liquor.											
June 20th - -	1·71	7·76	11·39	—	—	13·10	13·88	109·96	—	—	
Effluent.											
June 20th -	0·73	0·24	0·40	0·02	0·06	1·13	0·30	1·40	+	—	Effluent drawn soon after the start.
August 8th -	0·02	0·16	0·62	0·03	1·27	1·94	0·28	1·56	+	0·23	Effluent drawn when the filter had been going for about seven weeks.

Table 4.—Average Figures of Analysis for Filter treating Limed Steep Water alone. September—October, 1906.

Average volume treated = 5·2 gallons per cube yard per 24 hours.

Parts per 100,000.

	Limed Steep Liquor.			Effluent.				
	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	"Oxygen absorbed" in 4 hours.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	"Oxygen absorbed" in 4 hours.	Nitric Nitrogen.	Alkalinity as CaO.
Average - - -	**0·97**	**2·48**	**56·30**	**0·03**	**0·14**	**2·59**	**0·83**	**10·1**
Highest - - -	1·82	3·67	86·07	0·08	0·25	4·40	1·68	11·4
Lowest - - -	0·52	1·53	39·35	0·02	0·04	1·50	0·46	6·7
No. of samples examined	3	3	11	3	3	11	5	7

Typical Analyses.

Date—1906.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Dissolved Oxygen taken up in 5 days.	Solids in suspension.	Volatile matter in those solids.	Solids by centrifuge (vols).	Alkalinity as CaO.
Limed Steep Water.													
October 22nd - -	1·82	3·67	5·56	—	—	7·38	4·94	54·45	171·4	—	—	1·0	—
Effluent.													
October 22nd - -	0·03	0·25	0·54	0·02	0·46	1·05	0·63	2·85	2·32	5·8	5·2	63·0	10·0

Table 5.—Average Figures of short Analyses for Filter treating Limed Liquor made from the whole of the Distillery Waste Liquids. November 1906 to June 1907. (*Cf.* Table 6 for more detailed analyses)

Average volume treated = 20 gallons per cube yard per 24 hours.

Parts per 100,000.

	Limed Liquor.	Effluent.					*Periods of rest given to filter.*	
		"Oxygen absorbed" in 4 hours:—						
	"Oxygen absorbed" in 4 hours.	Original Effluent.	Effluent after filtration through paper.	Nitrous and Nitric Nitrogen.	Alkalinity as CaO.	Incubator Test (by smell).	Nov. 18th—Nov. 29th. Dec. 13th—Dec. 16th. Frost. Dec. 25th, 1906—Jan. 6th, 1907. Frost and snow. Feb. 1st, 1907. 24 hours. Feb. 7th, 1907. 24 hours. Feb. 9th, 1907, 3½ days.	Feb. 24th and 25th. Frost and snow. March 7th—13th. Washing and replacing top 6 inches of coke. April 21st. Filter treated on the surface with solution of caustic soda.
Average - -	**98·8**	**3·95**	**3·59**	**1·06**	**13·5**			
Highest -	127·2	10·30	8·10	2·28	19·6	48 +		
Lowest - -	51·1	1·30	1·08	0·16	6·8	8 —		
No. of samples	64	60	55	30	36	56		

Typical Analyses.

Date.	Limed Liquor.	Effluent.					Remarks.
		"Oxygen absorbed" in 4 hours.					
	"Oxygen absorbed" in 4 hours.	Original Effluent.	Effluent after filtration through paper.	Nitrous and Nitric Nitrogen.	Alkalinity as CaO.	Incubator Test (by smell).	——
Jan. 8th, 1907.	51·16	3·27	3·12	0·90	17·5	+	These figures may be taken as representing:— Weak Limed Liquor and corresponding effluent;
Mar. 13th, 1907.	127·20	4·60	3·12	1·00	15·0	+	Strong Limed Liquor and corresponding effluent;
May 21st, 1907.	97·50	2·41	2·20	2·24	16·8	+	Average Limed Liquor and corresponding effluent.

Table 6.—Figures of the more detailed Analyses for Filter treating Limed Liquor made from the whole of the Distillery Waste Liquids, January 8th to June 30th, 1907.

Average volume treated = 20 gallons per cube yard per 24 hours.

(For average figures of short Analyses, *cf.* Table 5.)

Parts per 100,000.

Date—1907.	Limed Liquor.			Effluent.						Remarks.
	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	"Oxygen absorbed" in 4 hours.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Nitric Nitrogen.	"Oxygen absorbed" in 4 hours.	Incubation (by smell).	Alkalinity as CaO.	
Jan. 9th - -	0·60	2·90	56·16	0·17	0·25	0·89	3·12	+	13·2	
„ 16th - -	0·70	6·60	112·08	0·09	0·37	0·65	4·16	+	12·2	
„ 25th - -	0·60	7·60	117·60	0·12	0·31	0·33	3·96	+	12·2	
„ 31st - -	1·00	8·70	96·00	0·35	0·56	0·34	7·04*	—	12·0	Filter arms jammed during night—due to snow.
Feb. 15th - -	0·80	4·50	70·40	0·16	0·23	0·49	2·88	+	16·8	* This figure is not included in the average.
„ 19th - -	0·70	5·10	97·60	0·12	0·31	0·40	3·00	+	15·7	
„ 27th - -	0·50	5·60	108·00	0·30	0·34	0·49	3·84	+	18·7	
Mar. 4th - -	0·70	5·40	117·60	0·10	0·30	0·49	2·10	+	15·7	
„ 14th - -	1·10	4·50	116·20	0·35	0·13	1·20	3·40	+		A duplicate sample of this effluent, with its suspended solids, required for its complete oxidation (by oxygen dissolved in water) 8·8 parts of oxygen.
April 12th - -	1·00	6·70	92·46	0·08	0·32	1·41	1·40	+	16·8	
„ 25th - -	0·40	4·70	72·74	0·03	0·20	0·73	1·38	+	14·6	
May 7th - -	0·40	5·20	100·60	0·04	0·22	1·70	1·95	+	14·0	
„ 15th - -	0·40	6·80	97·50	0·02	0·15	2·28	2·34	+	17·3	A duplicate sample of this effluent, with its suspended solids, required for its complete oxidation (by oxygen dissolved in water) 6·7 parts of oxygen; and after paper filtration 2·8 parts.
„ 21st - -	0·60	6·80	97·50	0·04	0·24	2·24	2·41	+	16·8	
„ 28th - -	0·50	6·40	89·70	0·03	0·25	1·64	2·18	+	18·7	
June 5th - -	0·80	5·40	82·68	0·02	0·22	1·22	2·73	+	19·1	
„ 10th - -	1·00	4·80	68·80	0·06	0·19	1·62	1·76	+	19·6	
„ 19th - -	0·60	3·30	59·20	0·02	0·16	2·02	1·84	+	15·4	
Average - -	**0·69**	**5·61**	**92·0**	**0·12**	**0·28**	**1·12**	**2·61**		**15·8**	
Highest - -	1·10	8·70	117·6	0·35	0·56	2·28	4·16		19·6	
Lowest - -	0·40	2·90	56·1	0·02	0·15	0·33	1·38		12·0	
No. of samples -	18	18	18	18	18	18	17	18	17	

TABLE 7.—AVERAGE FIGURES of Analysis of Limed Liquor made from Pot-Ale only and of Effluent during the Salmon Experiments—November, 1907, to July 18th, 1908.

Average volume treated = 20 gallons per cubic yard per 24 hours.

Parts per 100,000.

No. of Sample.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (Scudder).	Incubation (by smell).	Oxygen in Solution.	Dissolved Oxygen taken up in 48 hours.	Dilution.	Dissolved Oxygen taken up in 5 days.	Dilution.	Solids in Suspension.	Volatile Matter in Suspended Solids.	Centrifuge Solids.	Chlorine.	Alkalinity as CaO.	Remarks.
Limed Liquor.																					
Average - -	**0·42**	**2·88**	—	—	—	**6·63**	**4·57**	**71·1**	—	—	—	—	Tap water. —	—	Tap water. —	**6·13**	**5·7**	**16·0**	**3·93**	—	A sample of effluent drawn on November 29th, 1907, was found to contain, in solution :— *Parts per 100,000 by weight.* Lime (CaO)* - - - 18·55 Magnesia (MgO) - - 3·12 Sulphuric Acid (SO_3)- - 11·54 Chlorine (Cl_2) - - - 4·09 Carbonic Acid (CO_2), free and combined together - 16·87 * This lime would contain a little magnesia.
Highest - -	0·80	4·30	—	—	—	9·07	6·67	103·2	—	—	—	—	—	—	—	8·9	8·4	26·7	4·34	—	
Lowest - -	0·20	1·40	—	—	—	4·41	2·89	38·8	—	—	—	—	—	—	—	0·8	0·7	trace	3·38	—	
No. of samples -	21	21	—	—	—	17	20	43	—	—	—	—	—	—	—	20	20	19	4	—	
Effluent.																					
Average - -	**0·03**	**0·14**	**0·36**	**0·02**	**0·66**	**1·13**	**0·43**	**175**	18 + 1 −	39 + 1 −	**0·74***	**0·32**	—	**0·77**	—	—	—	**trace**	—	**12·50**	
Highest - -	0·10	0·21	0·66	0·13	2·54	2·98	0·82	3·94	—	—	1·03*	0·75	—	2·52	—	—	—	—	—	15·8	
Lowest - -	0·01	0·08	0·18	0·00	0·00	0·47	0·07	0·48	—	—	0·35*	0·00	—	0·15	—	—	—	—	—	6·2	
No. of samples -	43	43	16	20	43	16	20	43	19	40	33	16	—	16	—	—	—	—	—	25	
											TYPICAL ANALYSES.										
Limed Liquor. Date.																					
March 25th, 1908 -	0·60	2·60	—	—	—	—	—	69·62	—	—	—	—	—	—	—	—	—	—	—	—	
April 22nd - -	—	—	—	—	—	5·74	3·65	60·12	—	—	—	—	—	—	—	7·0	7·0	26·7	—	—	
Effluent.																					
March 25th - -	0·04	0·16	—	—	0·40	—	—	1·92		+	4·40	—	—	—	—	—	—	—	—	12·96	
April 22nd - -	0·03	0·10	0·49	0·00	0·63	1·15	0·41	1·36	+	+	4·90	0·30	2 vols.	0·33	4 vols.	—	—	—	—	—	

* These figures are equivalent to 5·15, 7·21 and 2·46 c.c. per litre, respectively.

COLEBURN—*continued.*

TABLE 8.—AVERAGE PERCENTAGE purification, as measured by the reduction in "Oxygen absorbed" from "Strong" (*i.e.*, $\frac{N}{8}$) permanganate at 27° C., during the Salmon Experiments.

Parts per 100,000.

———	Limed Liquor.	Final Effluent.	Percentage purification.
Average	**77·9**	**1·77**	**97·8**
Highest	119·2	2·88	99·2
Lowest	41·6	0·48	95·6
No. of samples	89	89	89

TABLE 9.—OXYGEN in solution in Coleburn Effluent, during the period of the Salmon Experiments, before and after incubation for five days at 27° C. (80° F.). December, 1907—May, 1908.

*c.c. per litre.**

Date.	Before Incubation.	After incubation for 5 days at 27° C.	Remarks.
1907.			
Dec. 15th	6·8	Trace.	
„ 18th	5·8	Trace.	
„ 21st	6·1	Trace.	
„ 24th	5·7	3·5	
„ 27th	7·1	4·2	
„ 30th	6·7	0·5	
1908.			
Jan. 2nd	6·0	0·6	
„ 6th	5·6	0·6	
„ 10th	6·6	4·8	
„ 13th	6·5	5·9	
„ 16th	5·6	4·1	
„ 20th	7·3	6·4	No. of samples tested—34.
„ 24th	6·8	6·6	Average figure for Oxygen in effluent as entering the hatchery—5·6 c.c. per litre.
„ 28th	6·8	5·6	Highest figure for Oxygen in effluent as entering the hatchery—7·3 c.c. per litre.
Feb. 3rd	6·4	4·2	Lowest figure for Oxygen in effluent as entering the hatchery—3·6 c.c. per litre.
„ 7th	5·1	3·8	
„ 10th	5·2	4·3	Average figure for Oxygen in effluent after incubation—3·0.
„ 14th	5·6	3·2	Highest figure for Oxygen in effluent after incubation—6·6.
„ 18th	5·2	2·5	Lowest figure for Oxygen in effluent after incubation—Trace.
„ 24th	4·1	3·0	
„ 28th	5·7	4·1	
Mar. 4th	6·3	2·1	
„ 10th	6·4	1·0	
„ 12th	6·4	Trace.	
„ 18th	4·1	2·9	
„ 25th	4·4	3·5	
April 3rd	4·6	3·5	
„ 8th	4·4	3·5	
„ 14th	4·8	2·1	
„ 21st	5·1	4·3	
„ 25th	5·1	4·5	
May 1st	3·0	0·7	
„ 5th	4·8	4·1	
„ 13th	5·2	3·5	

* 7 c.c. of Oxygen per litre are equivalent to 1 part by weight of oxygen per 100,000 parts of liquid.

TABLE 10.—AVERAGE FIGURES OF ANALYSIS for Filter treating Limed Steep Water alone. November—December 1908.

Average volume treated = 8 to 9 gallons per cube yard per 24 hours.

Parts per 100,000.

Date, 1908.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (by smell).	DissolvedOxygen taken up in 48 hours.	Dilution.	DissolvedOxygen taken up in 4 days.	Dilution.	DissolvedOxygen taken up in 6 days.	Dilution.	Solids in Suspension.	Volatile Matter in Suspended Solids.	Centrifuge Solids.	Ratio of Suspended Solids to Centrifuge Solids.	Remarks.
Limed Steep Water.																				
Average - -	**1·91**	**2·63**	**4·93**	—	—	**6·90**	**6·94**	**74·11**	—	**136·9**	149 to 249 vols. tap water.	**156·2**	249 to 399 vols. tap water.	**193·9**	399 to 599 vols. tap water.	**6·0**	**5·3**	**13·8**	**1 : 2·3**	
Highest - -	2·68	3·68	7·57	—	—	9·81	7·72	96·83	—	182·5	—	186·0	—	216·2	—	7·1	6·3	21·8	1 : 3·2	
Lowest - -	0·51	1·87	4·02	—	—	4·53	6·02	55·50	—	100·7	—	126·3	—	161·2	—	4·8	3·9	2·9	1 : 0·6	
No. of samples -	4	4	4	—	—	4	4	4	—	3	—	2	—	3	—	4	4	4	4	
Effluent BEFORE *passing sand beds.*																				
Average - -	**0·04**	**0·19**	**0·39**	**0·00**	**1·23**	**1·66**	**0·67**	**2·92**	**4 +**	**0·23**	2 to 9 vols.	5 days. **0·65**	4 to 19 vols.	—	—	—	—	[illegible]	—	
Highest - -	0·05	0·26	0·62	—	2·52	2·91	0·81	4·05		0·53	—	1·08	—	—	—	—	—	·3	—	
Lowest - -	0·02	0·13	0·27	—	0·44	1·10	0·49	2·04		0·02	—	0·28	—	—	—	—	—	1·8	—	
No. of samples -	4	4	4	4	4	4	4.	4	4	4	—	4	—	—	—	—	—	4	—	
Effluent AFTER *passing sand beds.*																				
Average - -	**0·03**	**0·17**	—	**0·00**	**0·87**	**1·21**	**·66**	**2·74**	**3 +**	**0·18**	—	5 days. **0·52**	**2** vols.	—	—	—	—	**·9**	—	
Highest - -	0·04	0·18	—	—	1·14	1·34	0·72	3·10		0·22	—	0·79	—	—	—	—	—	1·1	—	
Lowest - -	0·02	0·16	—	—	0·66	1·08	0·59	2·43		0·13	—	0·30	—	—	—	—	—	0·7	—	
No. of samples -	3	3	—	3	3	2	3	3	3	3	—	3	—	—	—	—	—	2	—	

TABLE 11.—FUNGI and WEEDS from Coleburn, etc., June, 1907.

Description.	Analysis of the teased and pressed samples.*									*Notes and remarks on the original samples before they were cleansed.
	Parts, per cent.			Calculated on weed dried at 105°C. *Parts per cent.*						
	Moisture at 105°C.	Volatile matter.	Non-Volatile matter.	Siliceous Grit.	Total Sulphur.	Sulphurextracted by 1 per cent. H.Cl. in the cold in 30 hours.	Total Phosphorus.	Phosphorus extracted by 1 per cent. H.Cl. in the cold in 30 hours.	Total Nitrogen.	
No. 53. *Fungus* taken from channel, that had been carrying a 5 per cent. solution of pot-ale, on June 16th, 1907. Dirty pink, grey and green growths, partially—at least—putrefying.	82·69	13·97	3·34	12·70	0·64	0·085 (=0·213 SO_3)	1·66	1·12 (=2·56 P_2O_5)	—	Green and pink growths, possessing a most nauseating stench. Very few worms present.
No. 52. *Rhizoclonium hieroglyphicum.* Dark green weed from efflueut channel, with some effluent solids, but consisting chiefly of Rhiz. hierog. (June 16th, 1907).	70·26	27·15	2·59	3·87	1·21	0·13 (=0·33 SO_3)	0·72	0·34 (=0·77 P_2O_5)	—	Dark olive-green weeds, containing a large number of worms and slugs.
No. 51. *Weeds from water supply channel* (June 16th, 1907). Bright green and filled with air bubbles.	78·19	19·92	1·89	—	0·57	0·29 (=0·72 SO_3)	0·24	0·13 (=0·30 P_2O_5)	—	Dark olive-green fibrous weeds. Strong seaweed smell; rather few worms.
Leptomitus lacteus from the Foths Burn near Glen Lossie Distillery (June 16th, 1908).	81·5	16·4	2·1	1·18	0·64	—	1·32	—	6·68	White filamentous weeds; a great quantity of broken down vegetable matter, with grit and dead worms.
Green Algæ from the Cole Burn above the Coleburn distillery (June 16th, 1908).	72·1	22·6	5·3	11·63	1·48	—	0·49	—	3·23	Green hair-like weeds.

* *Process of estimation.*—The weeds were carefully teased out in water by means of forceps, in very small portions at a time, and in this way were freed from worms, larvæ, sand and other extraneous matter as carefully as possible. The purified weed (which probably did not contain more than 1 to 3 per cent. of foreign matter) was then pressed between layers of filter paper.

TABLE 12.—AIR-DRIED PRECIPITATION SLUDGE.

Description of sample.	Parts per cent.							Remarks.
	Moisture at 105° C.	Volatile matter.	Non-volatile matter.	Phosphoric Acid (P_2O_5), by extraction with Hydrochloric Acid.	Equivalent to Tribasic phosphates of lime, $Ca_3(PO_4)_2$.	Phosphoric Acid (P_2O_5), by preliminary oxidation with strong Nitric Acid.	Total Nitrogen (by Kjeldahl method).	
Air-dried Sludge from settling tanks which had been exposed to the air for about 6 weeks. Received April 19th, 1907. Sub-sampled April 22nd, 1907.	46·23	9·18	44·59	5·15	11·25	—	—	
Air-dried sludge. Sample taken April 30th, 1908.	29·13	6·74	64·13	2·66*	5·81	2·62*	0·80 (mean of 7 estimations),	* The agreement between those two figures shows that the phosphorus is all (or practically all) present in the sludge as phosphate of lime.

COLEBURN—*continued.*

TABLE 13.—EXPERIMENT made to test the effect of the addition of Nitrate of Soda ($NaNO_3$), during three successive days, to the Limed Liquor before it was sprinkled on to the filter. The Nitrate was added in quantities equivalent to 10, 10 and 20 parts of Nitric Nitrogen per 100,000 parts of liquor. (June, 1908.)

Volume treated = 20 gallons per cube yard per 24 hours.

Parts per 100,000.

No. of sample.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (Scudder).	Incubation (by smell).	Dissolved Oxygen taken up in 48 hours.	Dilution.	Dissolved Oxygen taken up in 5 days.	Dilution.	Solids in Suspension.	Volatile Matter in Suspended Solids.	Centrifuge Solids.	Ratio of Suspended Solids to Centrifuge Solids.	Remarks.
Limed Liquor.																			
June 19th - -	—	—	—	—	—	7·11	5·22	51·18	—	—	—	—	—	—	—	—	12·3	—	
„ 20th - -	—	—	—	—	—	7·06	4·85	47·00	—	—	—	—	—	—	—	—	10·3	—	
„ 21st - -	—	—	—	—	—	6·53	5·83	76·66	—	—	—	—	—	—	—	—	10·4	—	
„ 22nd - -	—	—	—	—	—	6·63	5·83	77·18	—	—	—	—	—	—	—	—	18·1	—	
Effluent.	Analysis done on paper-filtered samples.														Analysis done on original samples.				
June 19th -	0·02	0·12	0·12	0·00	2·37	2·51	0·36	1·21	+	+	0·10	2 vols. tap water.	0·19	4 vols. tap water.	28·2	19·9	492·0	1 : 17·4	Sample drawn before the addition of Sodium Nitrate.
„ 19th - -	0·04	0·12	0·25	0·02	1·94	2·35	0·48	1·25	+	+	0·14	2 vols. tap water.	0·21	4 vols.	44·8	31·7	774·6	1 : 17·3	Average of 5 sub-samples; 10 parts Nitric Nitrogen added as Sodium Nitrate to Limed Liquor.
„ 20th - -	0·07	0·12	0·45	0·04	1·84	2·40	0·56	1·71	+	+	0·02	2 vols. tap water.	0·20	4 vols.	47·6	32·8	851·0	1 : 17·9	Average of 5 sub-samples; 10 parts Nitric Nitrogen added as Sodium Nitrate to Limed Liquor.
„ 21st - -	0·06	0·14	0·24	0·12	1·53	1·95	0·61	1·86	+	+	0·17	2 vols. tap water.	0·45	4 vols.	74·0	53·8	1182·0	1 : 14·4	Average of 5 sub-samples; 20 parts Nitric Nitrogen added as Sodium Nitrate to Limed Liquor.
„ 22nd -	0·04	0·15	0·20	0·06	1·88	2·18	0·52	1·63	+	+	0·10	2 vols. tap water.	0·29	4 vols.	28·3	20·2	496·0	1 : 17·5	Average of 5 sub-samples; no Sodium Nitrate added.

TABLE 14.—Experiment made to test the effect of the addition of Sulphate of Ammonia, $(NH_4)_2SO_4$, during three successive days, to the Limed Liquor. The Sulphate was added in quantities equivalent to 10, 10 and 17 parts of Ammoniacal Nitrogen per 100,000 parts of liquor. (June, 1908.)

Volume treated = 20 gallons per cube yard per 24 hours.

Parts per 100,000.

Date—1908.	Ammoniacal Nitrogen.	Albuminoid Nitrogen	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (Scudder).	Incubation (by smell).	Dissolved Oxygen taken up in 48 hours.	Dilution.	Dissolved Oxygen taken up in 5 days.	Dilution.	Solids in Suspension.	Volatile Matter in Suspended Solids.	Centrifuge Solids.	Ratio of Suspended Solids to Centrifuge Solids.	Remarks.
Limed Liquor.												Tap water.		Tap water.					
June 23rd - -	—	—	—	—	—	6·21	5·60	72·69	—	—	—	—	—	—	—	—	15·2	—	
,, 24th - -	—	—	—	—	—	6·58	5·49	75·20	—	—	—	—	—	—	—	—	9·0	—	
,, 25th - -	—	—	—	—	—	6·90	6·10	83·50	—	—	—	—	—	—	—	—	33·4	—	
,, 26th - -	—	—	—	—	—	6·79	5·95	77·81	—	—	—	—	—	—	—	—	46·1	—	
,, 27th - -	—	—	—	—	—	7·44	6·10	77·08	—	—	—	—	—	—	—	—	38·0	—	
,, 28th - -	—	—	—	—	—	6·31	6·40	57·76	—	—	—	—	—	—	—	—	10·4	—	
	Analysis done on paper-filtered samples.														Analysis done on original samples.				
Effluent.												vols.		vols.					
June 23rd - -	0·04	0·14	0·19	0·05	1·69	1·97	0·21	1·46	+	+	0·00	2	0·11	4	36·0	25·2	590·6	1 : 16·4	Sample taken before the addition of Ammonium Sulphate.
,, 24th - -	0·37	0·15	0·63	0·05	2·51	3·56	0·25	1·46	+	+	0·14	2	0·37	4	26·9	19·0	456·0	1 : 17·0	Average of 5 sub-samples; 10 parts of Nitrogen per 100,000 as Ammonium Sulphate added to the Limed Liquor.
,, 25th - -	0·99	0·16	0·81	0·35	3·17	5·32	0·58	1·71	+	+	0·19	2	0·23	4	20·5	14·5	366·0	1 : 17·8	Average of 5 sub-samples; 10 parts of Nitrogen per 100,000 as Ammonium Sulphate added to the Limed Liquor.
,, 26th - -	1·79	0·14	?	0·38	5·72	7·89	0·52	1·25	+	+	0·02	2	0·37	4	32·2	22·6	556·0	1 : 17·3	Average of 5 sub-samples; 17 parts of Nitrogen per 100,000 as Ammonium Sulphate added to the Limed Liquor.
,, 27th - -	0·76	0·14	0·44	0·30	6·46	7·96	0·54	1·61	+	+	0·15	2	0·35	4	28·9	19·7	538·4	1 : 18·6	Average of 5 sub-samples; no Ammonium Sulphate added to the Limed Liquor.
,, 28th - -	0·10	0·17	1·05	0·06	3·94	5·15	0·43	1·25	+	+	0·22	2	0·27	4	33·3	23·7	576·0	1 : 17·3	Average of 5 sub-samples; no Ammonium Sulphate added to the Limed Liquor.
,, 29th - -	0·03	0·10	0·14	0·00	4·16	4·33	0·11	0·96	+	+	0·00	2	0·02	4	13·2	7·5	252·4	1 : 19·1	Average of 5 sub-samples; no Ammonium Sulphate added to the Limed Liquor.
*Effluent from the filter, now receiving dam water only.**																			
June 30th - -	0·12	0·11	—	0·02	3·26	3·30	0·23	1·10	+	+	0·07	2	0·23	4	41·6	29·0	710·0	1 : 17·1	* Average of 5 sub-samples taken over a period of 24 hours.
July 1st - -	0·04	0·10	—	0·02	3·70	3·85	0·18	0·82	+	+	0·07	2	0·23	4	31·5	22·3	571·2	1 : 18·1	* ,, ,, ,, ,, ,
,, 2nd - -	0·03	0·09	—	0·04	4·16	4·19	0·21	0·68	+	+	0·03	2	0·10	4	22·4	15·6	366·0	1 : 16·3	* ,, ,, ,, ,, ,,
,, 3rd - -	0·04	0·09	—	0·07	3·93	4·07	0·25	0·86	+	+	0·10	2	0·13	4	37·6	27·2	556·0	1 : 14·8	* ,, ,, ,, ,, ,,

* *Note.*—Filter was treated with 4,000 gallons of dam water per 24 hours, instead of Limed Liquor, during this period.

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TABLE 15.—Treatment on Contact Beds of Diluted and Limed Pot-Ale.

Parts per 100,000.

—	Limed Liquor.				Effluent after Six Contacts.						Remarks.
	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	"Oxygen absorbed" in 4 hours.	No. of fillings per week.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Nitric Nitrogen.	"Oxygen absorbed" in 4 hours.	Alkalinity as CaO.	Incubator test (by smell).	
First Experiment.—April 11th to June 30th, 1907.											
Average - -	**0·48**	**2·53**	**50·0**	3	**0·05**	**0·25**	**0·19**	**4·00**	**12·04**	2 passed 3 failed 1 doubtful	From February 28th to March 15th, 1907, the beds received two fillings per week of a 10 per cent. solution of pot-ale, limed and settled, and from March 15th to April 10th two fillings per week of a 5 per cent. solution. It has not been thought necessary to give the figures of analysis for this preliminary period. From April 11th to June 30th, 1907, the beds received three fillings per week of a 5 per cent. solution of pot-ale, limed and settled. After this first experiment the beds were reconstructed.
Highest - -	0·80	3·60	74·1	—	0·08	0·32	0·33	6·48	14·2		
Lowest - -	0·20	0·80	32·1	—	0·04	0·14	0·05	1·20	9·8		
No. of samples -	7	7	6	—	8	8	8	8	6	6	
**Second Experiment.—January 1st to April 27th, 1908.*											
Average - -	**0·63**	**1·95**	**61·90**	4	**0·03**	**0·13**	Most of the samples contained a trace only.	**2·45**	**10·64**	7 passed 6 failed	Similarly, the earlier figures obtained during the period of maturing of the beds in the second experiment (some five weeks) are not given. From January 1st to April 27th, 1908, the beds received four fillings per week of a 5 per cent. solution of pot-ale, limed and settled.
Highest - -	1·22	2·70	92·90	—	0·08	0·24	0·20	5·15	12·48	—	
Lowest - -	0·22	1·03	44·26	—	0·02	0·08	0·00	1·04	9·60	—	
No. of samples -	6	6	8	—	13	13	10	13	9	13	

* More detailed analyses of some of the samples examined between March and June, 1908, are to be found in Table 17. The actual quantity treated in this experiment was about 0·33 gallon of pot-ale per cube yard per day, for six days in the week.

—	Limed Liquor.	Fifth Contact Effluent.		Sixth Contact Effluent.		Remarks.
	"Oxygen absorbed" in 4 hrs.	"Oxygen absorbed" in 4 hrs.	Incubator test (by smell).	"Oxygen absorbed" in 4 hrs.	Incubator test (by smell).	
† *Third Experiment.—April 28th to June 24th, 1908.*						
(*a*) April 28th to May 16th.						
Average - -	**53·3**	**11·29**	All very putrid, with H_2S	**5·64**	All very putrid, with H_2S	April 28th, six fillings per week of a 5 per cent. pot-ale solution, limed and settled.
Highest - -	72·0	24·00		10·00		
Lowest - -	43·2	4·24		3·20		
No. of samples -	6	6	6	6	6	
(*b*) May 16th to June 1st.						
Average - -	**52·8**	**8·80**	All very putrid, with H_2S	**4·61**	All very putrid, with H_2S	May 18th, twelve fillings per week of a 5 per cent. pot-ale solution, limed and settled; *i.e.*, two fillings a day, six days a week.
Highest - -	60·8	10·4		8·24		
Lowest - -	44·0	7·2		2·48		
No. of samples -	4	4	4	4	4	
(*c*) June 1st to June 24th.						
Average - -	**75·0**	**8·30**	All very putrid, with H_2S	**4·89**	All very putrid, with H_2S	June 1st.—Strength of limed liquor doubled, with the same rate of treatment continued
Highest - -	96·0	11·20		7·36		
Lowest - -	45·6	3·04		2·48		
No. of samples -	11	9	9	19	19	

† The actual quantities treated during this third experiment were about (*a*) 0·5, (*b*) 1·0, and (*c*) 2·0 gallons of pot-ale per cube yard per day, for 6 days in the week.

TABLE 16.—Treatment of Diluted Pot-Ale on a Percolating Filter, without the previous addition of Lime.—February to July, 1907.

The detailed figures for this experiment are given in Appendix II.

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TABLE 17.—Figures of Analysis of Limed Liquor, made from Pot-ale, and of 6th Contact Effluent from the Mortlach beds. March—June, 1908.

The volume of liquor treated varied from 6·6 to 20 gallons per cube yard per 24 hours.

Parts per 100,000.

Date—1908.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (by smell).	Dissolved Oxygen taken up in 48 hours.	Dilution.	Dissolved Oxygen taken up in 5 days.	Dilution.	Dissolved Oxygen taken up in 192 to 249 days.	Dilution.	Solids in Suspension.	Volatile Matter in Suspended Solids.	Centrifuge Solids.	Ratio of Suspended Solids to Centrifuge Solids.	Chlorine.
Limed Liquor.																				
March 6th	—	—	—	—	—	—	5·15	92·90	—	36·0	99 vols. tap water	64·0	199 vols.	—	—	4·6	4·4	23·6	1 : 5·1	3·03
„ 17th	—	—	—	—	—	3·76	3·05	50·44	—	—		—	—	206·7	999 vols. tap water.	2·9	2·7	12·6	1 : 4·3	2·21
April 7th	0·22	2·08	3·43	—	—	3·65	2·92	44·26	—	35·1	79 vols.	64·2	149 vols.	203·2	749 vols.	3·5	2·9	7·0	1 : 2·0	2·31
May 19th	0·28	2·24	3·81	—	—	4·19	2·84	41·96	—	18·5	79 „	62·0	149 „	—	—	—	—	32·1	—	2·27
June 3rd	0·70	3·80	6·27	—	—	6·97	6·11	78·85	—	—	—	119·0	199 „	—	—	—	—	5·6	—	2·95
„ 15th	0·79	3·10	7·40	—	—	8·19	7·05	82·70	—	—	—	113·3	199 „	—	—	—	—	9·4	—	3·28
Average	**0·50**	**2·81**	**5·23**	—	—	**5·35**	**4·35**	**64·35**	—	**29·9**	—	**84·1**	—	—	—	**3·7**	**3·3**	**15·1**	—	**2·68**
Highest	0·79	3·80	7·40	—	—	8·19	7·05	92·90	—	36·0	—	119·0	—	—	—	4·6	4·4	32·1	—	3·28
Lowest	0·22	2·08	3·43	—	—	3·65	2·84	41·96	—	18·5	—	62·0	—	—	—	2·9	2·7	5·6	—	2·21
No. of Samples	4	4	4	—	—	5	6	6	—	3	—	5	—	—	—	3	3	6	—	6
Effluent from 6th contact bed corresponding to the above liquor.																				
March 6th	0·02	0·24	0·50	0·00	0·00	0·65	0·50	5·15	Failed.	3·42	4 vols.	—	—	—	—	2·2	1·7	1·8	1 : 0·8	2·31
„ 17th	0·02	0·11	0·25	0·00	0·00	0·25	0·31	1·63	„	0·31	4 „	0·90	9 vols.	8·5	49 vols.	—	—	Trace	—	—
April 7th	0·03	0·10	0·41	0·00	0·00	0·64	0·54	3·12	„	1·70	4 „	3·10	9 „	9·4	49 „	—	—	Trace	—	1·96
May 19th	0·01	0·13	0·36	0·00	0·00	0·37	0·23	1·61	„	1·26	4 „	1·23	9 „	—	—	—	—	1·7	—	—
June 3rd	0·03	0·30	0·56	0·00	0·00	0·59	0·65	4·72	„	—	—	5·46	19 „	—	—	—	—	Trace	—	3·14
„ 15th	0·06	0·32	0·52	0·00	0·00	0·68	0·96	6·00	„	4·42	9 vols.	7·46	19 „	—	—	—	—	Trace	—	2·77
Average	**0·03**	**0·20**	**0·43**	**0·00**	**0·00**	**0·53**	**0·53**	**3·21**	6 failed, with H_2S present in all of them after incubation.	**2·22**	—	**3·63**	—	—	—	—	—	**Trace**	—	**2·59**
Highest	0·06	0·32	0·56	—	—	0·68	0·96	6·00	—	4·42	—	7·46	—	—	—	—	—	—	—	3·14
Lowest	0·01	0·10	0·25	—	—	0·25	0·23	1·61	—	0·31	—	0·90	—	—	—	—	—	—	—	1·96
No. of Samples	6.	6	6	6	6	6	6	6	6	5	—	5	—	—	—	—	—	6	—	4

TABLE 18.—FIGURES OF ANALYSIS of Limed Liquor, made from Steep Water only, and of 3rd and 6th Contact Effluents from the Mortlach Beds. November—December, 1908.

The volume of liquor treated was 20 gallons per cube yard per 24 hours.

Parts per 100,000.

Date, 1908.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (by smell.)	Dissolved Oxygen taken up in 48 hours.	Dilution.	Dissolved Oxygen taken up in 5 days.	Dilution.	Solids in Suspension.	Volatile matter in Suspended Solids.	Centrifuge Solids.	Ratio of Suspended Solids to Centrifuge Solids.
											Vols. tap water.		Vols. tap water.				
Limed Steep Water.																	
Nov. 16th - -	1·22	1·02	2·14	—	—	3·36	3·41	25·73	—	34·0	99	69·0	149	5·0	4·8	5·0	1 : 1·0
„ 23rd - -	1·89	1·44	3·47	—	—	5·36	5·58	39·32	—	—	—	—	—	7·4	6·4	15·2	1 : 2·1
Dec. 9th - -	0·89	1·69	2·09	—	—	3·98	4·85	45·90	—	59·0	199	85·5	299	4·9	4·7	8·4	1 : 1·7
„ 14th - -	1·34	2·43	4·78	—	—	6·12	6·09	59·30	—	83·8	199	131·1	299	6·7	6·3	12·3	1 : 1·8
„ 22nd - -	2·28	4·18	6·90	—	—	9·18	7·32	84·50	—	—	—	—	—	7·9	7·6	—	—
Average - -	**1·52**	**2·15**	**3·88**	—	—	**5·60**	**5·45**	**50·95**	—	**58·9**	—	**95·2**	—	**6·4**	**6·0**	**10·2**	**1 : 1·6**
Highest - -	2·28	4·18	6·90	—	—	9·18	7·32	84·50	—	59·0	—	131·1	—	7·9	7·6	15·2	—
Lowest - -	0·89	1·02	2·14	—	—	3·36	3·41	25·73	—	34·0	—	69·0	—	4·9	4·7	5·0	—
No. of Samples	5	5	5	—	—	5	5	5	—	3	—	3	—	5	5	4	4
Effluent from 3rd Contact Bed.																	
Nov. 16th - -	0·15	0·29	0·53	—	—	0·68	1·08	5·41	—	7·0	99	12·0	149	—	—	0·7	—
„ 23rd - -	0·95	0·97	1·88	—	—	2·83	4·09	27·64	—	49·2	99	77·3	149	—	—	6·3	—
Dec. 9th - -	0·56	3·57	5·29	—	—	5·85	7·16	59·44	—	96·0	249	171·0	499	—	—	20·1	—
„ 14th - -	1·18	1·74	2·55	—	—	3·73	4·52	42·89	—	67·0	199	90·3	299	5·2	4·9	8·7	1 : 1·7
„ 22nd - -	1·26	2·26	4·54	—	—	5·80	5·44	59·80	—	—	—	—	—	—	—	—	—
Average - -	**0·82**	**1·77**	**2·96**	—	—	**3·78**	**4·47**	**39·04**	—	**5·48**	—	**87·7**	—	—	—	**9·0**	—
Highest - -	1·26	3·57	5·29	—	—	5·85	7·16	59·80	—	96·0	—	171·0	—	—	—	20·1	—
Lowest - -	0·15	0·29	0·53	—	—	0·68	1·08	5·41	—	7·0	—	12·0	—	—	—	0·7	—
No. of Samples	5	5	5	—	—	5	5	5	—	4	—	4	—	—	—	4	—
Effluent from 6th Contact Bed.																	
Nov. 16th - -	0·05	0·29	0·44	0·00	0·00	0·49	0·74	4·23	Failed.	—		3·40	6	—	—	2·5	—
„ 23rd - -	0·04	0·32	0·85	0·00	0·00	0·89	1·84	6·20	„ „	3·40+x	4	8·83+x	9	3·2	21·0	5·0	1 : 1·6
Dec. 9th - -	0·04	0·37	0·83	0·00	0·00	0·87	1·42	9·80	„ „	9·59+x	9	18·24+x	19	—	—	2·2	—
„ 14th - -	0·15	0·41	0·87	0·00	0·00	1·02	1·54	11·86	„ „	14·04	29	19·27	74	—	—	2·9	—
„ 22nd - -	0·20	0·74	1·48	0·00	0·00	1·68	1·78	19·49	—	—	—	—	—	—	—	—	—
Average - -	**0·10**	**0·43**	**0·90**	**0·00**	**0·00**	**0·99**	**1·48**	**10·12**	*5 failed, with H_2s present in all of them after incubation.	—	—	—	—	—	—	**3·2**	—
Highest - -	0·20	0·74	1·48	—	—	1·68	1·84	19·49		—	—	—	—	—	—	5·0	—
Lowest - -	0·04	0·29	0·44	—	—	0·49	0·74	4·23		—	—	—	—	—	—	2·2	—
No. of Samples	5	5	5	5	5	5	5	5		—	—	—	—	—	—	5	—

Assumed in the case of the last sample.

TABLE 19.—SAMPLES OF GRAIN DISTILLERY WASTE LIQUORS (FROM WATNEY & CO.'S DISTILLERY, WANDSWORTH).

Parts per 100,000.

Date.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Total Organic Nitrogen.	Nitrous Nitrogen.	Nitric Nitrogen.	Total Nitrogen.	"Oxygen absorbed" at once.	"Oxygen absorbed" in 4 hours.	Incubation (by smell).	Dissolved Oxygen taken up in 2 and 3 days.	Dilution.	Dissolved Oxygen taken up in 5 days.	Dilution.	Dissolved Oxygen taken up in 7 days.	Dilution.	Total Solids.	Solids in Suspension.	Volatile matter in Suspended Solids.	Centrifuge Solids.	Ratio of Suspended Solids to Centrifuge Solids.	Solids in Solution.	Remarks.
											Vols of tap water.		Vols. of tap water.		Vols. of tap water.							
Spent Waste (Residue in the first 'Coffey' still).																						
Nov. 17th, 1908	1·02	65·00	154·7	—	—	155·7	53·8	1,133·6	—	1,286·0 (3 days).	2,000*	1,946·0	3,500	2,235·0	5,000	2,666·0	1,524·0	1,500·0	25,320·0	1 : 16·6	1,142·0	Specific Gravity = 1·0105. This was a very thick grey liquid, with a clean and slightly spirituous smell.
Jan. 18th, 1909	1·14	26·8	64·2	—	—	65·33	47·95	526·8	—	396·7 (2 days).	1,000	850·4	2,000	—	—	955·0	571·0	559·5	8960·0	1 : 15·7	384·0	
After paper filtration - -	1·08	13·5	22·1	—	—	23·13	23·97	225·6	—	217·8 (2 days).	500	431·6	1,000									
Spent Wash (as run into the sewer).																						
Nov. 17th, 1908	1·44	21·80	—	—	—	55·3	16·4	757·5	—	739·5 (3 days).	1,500	1,218·0	2,000	1,347·0	3,000	1,159·0	187·4	181·4	960·0	1 : 5·1	971·6	This had the same appearance and smell as the spent waste, excepting that it was much less thick.
Jan. 18th, 1909	1·44	15·70	33·8	—	—	35·27	37·92	357·2	—	304·2 (2 days).	500	594·2	1,000	—	—	219·5	137·5	136·5	577·6	1 : 4·3	82·0	
After paper filtration - -	1·44	12·56	24·7	—	—	26·16	25·36	305·3	—	261·0 (2 days).	500	557·5	1,000									
Barley Steep Water (as discharged into the sewer).																						
Nov. 20th - -	0·41	0·82	2·90	0·30	0·00	3·61	3·14	24·70	Putrid, with H_2S present.	20·6 (2 days).	75	28·6	150	—	—	167·7	1·8	1·7	0·7	1 : 0·4	166·0	This was a brownish and opalescent liquid, with a faint smell like treacle, and with practically no suspended solids.

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* The volume of tap water used for this dilution was actually 1,999, *i.e.*, 1 volume of water less than is given in the Table. The same remark applies to the other cases.

APPENDIX VI.

REPORT BY MR. STEVENSON MACADAM ON THE EXPERIMENTAL WORKS AT COLEBURN DISTILLERY.

Analytical Laboratory,
55, York Place, Edinburgh.
15*th July*, 1908.

EXPERIMENTAL WORKS OF ROYAL COMMISSION ON SEWAGE DISPOSAL AT COLEBURN DISTILLERY.

Report by Mr. Stevenson Macadam.

I beg to report that in accordance with instructions received from Messrs. John C. Brodie & Sons, W.S., Edinburgh, I proceeded to Coleburn Distillery on the morning of 3rd June, 1908, for the purpose of making an examination of the experimental plant for the treatment of Distillery Waste Products, which was being operated there by the Royal Commission on Sewage Disposal.

I was accompanied by J. W. H. Grant, Esq., and Supt. MacGregor, and on arrival at the works I met Mr. R. D. Littlefield, resident chemist of the Commissioners, and Mr. Robertson, proprietor of the distillery.

The plant was in every day operation, and Mr. Littlefield fully explained to me the details of the apparatus, the nature and method of applying the liquids under treatment, and the final disposal of the effluent.

The apparatus itself consists of :—

1st.—A wooden vat in which milk of lime is prepared by agitating ordinary caustic lime with water.

2nd.—Two vats or tanks in which crude distillery waste is received, diluted with a requisite quantity of water and milk of lime, and settled for a given period.

3rd.—An automatic apparatus for registering and regulating the liquid passing from the settling tanks to the percolating filter.

4th.—A large openly constructed percolating filter on which the liquid from the automatic register is distributed by means of a mechanical "sparger," worked by the flow of liquor, and

5th.—A sand filter through which the effluent from the percolating filter passes before it is finally discharged.

The crude material under treatment at the time of my inspection was burnt ale alone, with no other distillery refuse, but I might here mention that I had an opportunity of visiting the works in April of last year, and at that time mixed distillery waste, approximately in the proportions produced in a distillery, including the lime washings, was under similar treatment.

The amount of dilution required at the beginning of the process is considerable, and in some instances the quantity of water required might be a serious drawback to the adoption of the process. The dilution has been arrived at by experiment, and the object in view is to get a liquid with an oxygen consuming power of approximately 100 per 100,000 parts. Working with burnt ale alone, this is attained by using one part of burnt ale and nine parts of water. With a mixed distillery waste, the proportions used are one part burnt ale, one and a half to two parts other mixed distillery waste, and seven to seven and a half parts of water. In either case it is a liquid containing one-tenth of burnt ale, and this is the mixture which receives the lime and is settled. It is claimed that stagnation of the distillery waste does not affect the process of purification, but without direct evidence on this point I would be doubtful.

The addition of the lime removes free acidity, and it also helps to precipitate a considerable proportion of the polluting matter, which is retained in the settling tanks. The proportion of lime required varies with the acidity, but in any case it is small, and the addition is stopped whenever the mixture shows a faint alkaline reaction.

The settled liquid is of a dirty white drumly appearance, and has a marked tendency to froth when agitated, but it is ready for distribution over the percolating filter.

This filter consists of a very open wooden framework filled with cinder graded to about the size of road metal. The liquid is distributed over the surface by means of a revolving "sparger," and it then trickles or percolates slowly downwards, and is received on a concrete floor, above which the filter is supported. The filter is 24 feet in diameter, and 12 feet deep. It contains approximately 200 cubic yards. Its whole action is ærobic, and it is therefore constructed in a manner which will allow free access of air in all directions. The liquid in passing through the filter has a large proportion of its organic matter removed by oxidation, and it is at the end of this stage the purifying influence claimed for the apparatus ceases. The liquid is found to have lost its drumly white appearance and tendency to froth, but it has acquired a larger or smaller proportion of black suspended matter.

For the removal of this suspended impurity two small sand filters have been constructed, and these mechanically remove the suspended matters, and the liquid becomes clear and transparent as it discharges.

The first dilution is the only one which takes place during the process.

The sludge produced in the settling tank is removed from time to time, and after being air-dried forms a poor quality of manure worth about 30s. per ton.

Heat is considered to accelerate the action of the filter, but it was found necessary in winter to protect it by means of wooden covers. No freezing up has taken place during the course of the experiments, but a heating apparatus was introduced as a precautionary measure. Personally I would be very much afraid of this as a weak point in the continuous working of the apparatus during the cold weather experienced in the Spey Valley.

To ascertain the composition of the liquids at different stages of the process, I took the following samples :—

1. Crude burnt ale from the tank before receiving any treatment.
2. Burnt ale diluted with water, limed and settled. Sampled as passing to the automatic flushing tank for delivery to the percolating filter, one part burnt ale and twelve parts water, which includes the water used with the lime.
3. Effluent from percolating filter before passing to sand filters.
4. Effluent after passing through sand filters.
5. Dam water used for diluting the burnt ale, and preparing the lime solution.

The analytical results which I have obtained from the foregoing samples are stated on the attached Table A, under numbers one to five.

In reviewing the results obtained no exact comparisons can be made, but some general information is available and useful.

As already stated the general dilution employed for burnt ale is nine parts of water, or water and other liquids, to one part of ale, but in the present instance, for reasons to be afterwards stated, the dilution was approximately one to twelve.

The analysis of the burnt ale only applies to the composition of the material which was in the tank at the particular time of sampling. The Coleburn Distillery has been silent all the year, and the supplies of ale for the experiments have been obtained by carting it from a neighbouring distillery. As a consequence the store of ale would be composed of many different qualities and ages, and it would be frequently subjected to disturbance and resettlement. This will not only effect the composition of the burnt ale, but it will similarly affect the analysis of the other liquids. It must also be kept in recollection that though the ale, after dilution and treatment with lime, is allowed a period of settlement before it is put in use, it is a twenty-four hours' supply, and consequently the first portions passed to the filter will have much less settlement than the last. Similarly the percolating filter being of large size, and the process of filtration slow, the effluent from it must vary from time to time, unless the purification was absolute, which it is not. The effluent from the sand filter will, to a certain extent, also vary from the same cause. To obtain exact data it would be necessary to procure numerous samples, taken at frequent intervals, and form averages. I see no reason, however, to assume that the samples at the different stages either represent the best, or the worst, though I am unable to regard them as average.

As previously stated, the purifying powers claimed for the apparatus and with the effluent from the percolating filter, and the results stated under No. 3, Table A, show the composition of the effluent which was passing away from it at the time of my inspection. When taking the sample I was allowed to assume that it fairly represented the work done. The results show that the liquid contained 68·16 grains of total solid matter per gallon, and 13·55 parts of total ammonias per million. Even in its diluted state this is a highly polluting liquid containing a very large proportion of nitrogenous organic matter. The sample contained much black solid matter in suspension, but it did not froth and was practically odourless.

The sample obtained after passing through the sand filter, No. 4, Table A, is of much better quality. The total solid matter is reduced to about one half, and the total ammonias to 1·92 parts per million. The liquid was clear and free from suspended impurity. This is still a polluting liquid, and the results clearly show that the sand filtration is a very necessary part of the process. The large fall in solids and ammonias is apparently due to the absence of the black suspended impurity, and to prove this point I made a partial analysis of a portion of the solid matter removed by filtration, and I obtained the following results :—

In 100 parts by weight of dry material.

* Organic and volatile matter	65 per cent.
Mineral matter	35 „
	100 „
* Containing nitrogen	5·27 „
Equal to ammonia	6·40 „

This is a highly nitrogenous organic material.

If the dilution at the beginning of the process is taken into consideration the figures become very much higher. Allowing that the dilution was even the normal of nine of water to one of ale, the following proportions are obtained :—

——	Effluent from Percolating Filter No. 3.	Effluent from Sand Filters No. 4.
Grains per gallon :—		
Total solid matter	681·6 gr.	339·2 gr.
In million parts :—		
Free and saline ammonia	20·000 parts	2·000 parts
Albuminoid ammonia	115·500 „	17·200 „

On three occasions between 1906 and 1907, I have had submitted to me samples of the fully treated effluent, and the results which I obtained on analyses are stated in table B. At the time these samples were taken mixed distillery effluent was being treated, and it may be convenient at this point to compare them with the present sample of effluent. Again, multiplying the figures by 10 it will be noticed that the total solids range from 430 to 469 grains per gallon; and the total ammonias from 16½ to 70 parts per million. The results are very dissimilar and show the great variations which occur in the effluent. They all agree generally, however, and prove that the effluent to be expected from the apparatus is one high in total solid matter, and rich in nitrogenous organic matter.

The works from their size are easy to control, and they have all along been under highly skilled supervision. No doubt the results obtained are the very highest that can be got, and better than would be obtained on a large working scale with ordinary attention. I am desirous of giving every credit to the work which has been done, and to the high degree of purity which has been obtained, but I cannot make any comparison between the quality of even the diluted discharge, and the quality of a natural pure water such as the River Spey and its tributaries.

I have calculated that the organic purification amounts to fully 90 per cent., as measured by the free and albuminoid ammonia before and after treatment. In making this calculation it is necessary to multiply the ammonias in the effluent by ten, to allow for the dilution which they undergo in the process. It must be remembered, however, that the discharge contains a high proportion of mineral solids, including nitrates and phosphates, and these are foreign to the natural river waters.

Regarding the question of the effect such a discharge would have upon fish life, and the production of noxious growths, if discharged into a body of fresh water, it is claimed that no bad results need be expected, and experiments which have been carried out at Coleburn to some extent substantiate this. When I was at the works last year the pure effluent, and the effluent diluted with water, were being passed along different artificial channels containing gravel, and this had been so for some time. I examined the channels and did not observe any indication of unhealthy growths. I also examined the small ditch into which the discharges passed, with a similar result. The ditch contained abundance of fresh green water plants, and they appeared healthy in every respect. This ditch ultimately joins the Cole Burn, and no effect was noticeable on the stream.

In December of last year a small experimental Hatchery was erected in connection with the purification works, and I understand that 3,000 salmon ova, placed in tanks fed by the effluent, all hatched out. When I was there in June I saw the young fish and some small parr in different sets of tanks. One set of tanks were entirely fed with pure effluent, and others with varying mixtures of effluent and water. The fish were all perfectly healthy and appeared to be thriving excellently. I also examined the artificial discharge track, from the hatchery to the ditch, and could not notice any sign of pollution. Owing to the very warm weather which had existed for some time no natural water was running in the ditch, and the small flow from the hatchery was lost in the ground before it reached the Cole Burn, so that observations could not be made there.

Referring back to the extra addition of water which was being used at the beginning of June, I was told it was on account of the extra water required for the hatchery. Till the hatchery was started in December, 1907, the purification plant was only worked six days a week, but after that the tanks had to be kept fed on the seventh day, and to obtain the necessary supply of effluent rather more water was added at the beginning of the process.

The results of my observations on the discharge tracks, ditch, and Cole Burn, and the results of the fish experiments, certainly show, that under circumstances as they exist at Coleburn, noxious growths are not produced, and fish thrive. I am of opinion that the presence of the discharge in a stream would not interfere with angling. The proportion of effluent from the experimental plant is no doubt small, about 4,000 gallons per twenty-four hours, but even this quantity bears a considerable relation to the volume of the water of the ditch, into which I saw it passing in 1907 without visible contamination. Though these appear very favourable results, I cannot take the responsibility of stating that similar conditions would follow if one distillery, or several distilleries, in the same locality, were working the process on a practical scale. In such a district as Dufftown, with its seven distilleries, capable of working some 11,250 bushels per week, yielding over 537,000 gallons of undiluted polluted water, or over 5,250,000 gallons of effluent, which would pass into comparatively small streams, with good spawning ground, the result might be very different.

So far reference has only been made to the total solid residue and the ammonias, but I must also take into account the large proportion of nitric acid compounds, and phosphoric acid compounds found in the effluents. Whether these bodies will contribute to the propagation of noxious growths is a point upon which no definite statement can be made, as the life history of such low forms of life is imperfectly understood. Their presence is in any case of no advantage, and they are foreign to the water of a pure unpolluted stream. It may therefore be assumed that they are unnecessary from nature's point of view. In all waters used for domestic supply their presence is highly objectionable, and is sufficient in most cases to cause the rejection of a water for such purposes.

This latter point now leads me to the consideration of the degree of purity which the riparian proprietors are by law entitled to obtain. I have previously only considered the probable effect of the effluents on fish life, and noxious growths, but in many instances the preservation of the water of the streams in regard to its utility for domestic use, and the other primary purposes, may be of higher importance.

The effluents I have examined show a high degree of purification, but they still retain objectionable polluting matter foreign to the pure natural waters of the district. How long their influence may be felt, or their presence detected in a body of water is a matter which can not be answered generally. Every case will vary from innumerable conditions and circumstances. It is possible to imagine a discharge being instantly lost beyond recognition in a large body of pure water, by enormous dilution. Equally a similar discharge might render a small body of useful water useless for a considerable distance, or until the natural purifying agencies of the stream or of a larger body of pure water which it joined, has obliterated its objectionable features. I understand that such circumstances are not to be considered, but that the discharge itself shall be of such purity that it will not require the assistance of the stream waters, either to dilute it to a particular degree, or aid in its purification. In other words, the streams are to be allowed to retain their full store of energy for the fulfilment of their natural functions, and are not to be utilised for the reception, or purification, of foreign material from the distilleries. Under such circumstances the effluents produced from the experimental plant at Coleburn will not meet the case.

The method of treating sewage matters by percolating or trickling filters has been studied since 1903, but I am not aware that it has been employed for treating distillery waste before, nor that it has been used with the object of obtaining the high degree of purification required in the present case. The principle is now recognised as the best and simplest form of disposal of ordinary sewage, and it seems likely it will supersede the older forms of bacterial treatment, chemical precipitation, and irrigation. The process can be worked continuously, and as long as very gross solid matters are excluded it works regularly, and is not so liable to clogging as the old form of contact bed. The construction is cheaper as the walls do not require to be built tight, as in a tank bed, in fact they are purposely built loose to allow free access of air. One great difficulty with this class of filter is the even distribution of the matter to be treated. Revolving sparging arms, such as are in use at Coleburn, are rapidly falling into disfavour on account of their liability to clog, and I should fancy also liability to freeze. Distributing channels give much trouble, and preference is now given to perforated distributing pipes, or to sprinkling nozzles of varying types worked by a slight head of pressure.

Referring more particularly to the adoption of this process, or other processes on similar lines for the purification of distillery waste, one point which should be very carefully considered is, that the burnt ale contains a great deal of valuable feeding material which can be made use of, and the entire object of any bacterial process is to wholly destroy it. I am therefore of opinion that the ultimate solution of this difficult question must be found in a process by which the valuable constituents are retained, and thus become a source of revenue to the distiller, and not in one which utterly destroys them, and costs money to do so. If this view is taken it utterly dispels any attempt at purification by bacteriological treatment, and if the conservation of the material can be accomplished, the mere fact of the process being an asset is the best guarantee which the riparian proprietors can have that the distiller will work the process to the best of his ability, and their advantage.

In regard to the capacity, and cost, of the percolating filter method of disposal, only a general idea can be formed at this stage of the inquiry. The capacity on a general scale can be fairly well estimated, but the particular construction best suited for a given case, and its cost, depends greatly on local circumstances and requirements, including the suitability of the ground obtainable.

The working capacity of a filter may be considered as equal to the treatment of 2·5 gallons of burnt ale, per cubic yard, per day, with a minimum depth of 10 feet of bed. This includes the necessary dilution by nine parts of water, or water and other distillery waste, to one part of ale, and the liming. The initial cost of a complete plant may be taken roughly at 20s. per cubic yard of filter required, and 10 per cent for depreciation and repairs.

Assuming reasonable and convenient conditions to exist for the erection of the plant, the probable requirements for a 1,000 bushel capacity distillery would be one 1,000 cubic yard filter, four yards deep, with a surface area of 250 square yards, costing with necessary tanks, distributers, and other details, £1,000. If pumping were required, an extra expense would be incurred.

The daily working of such a plant does not entail much labour, and it is said one ordinary intelligent workman is sufficient, provided skilled aid be at hand should difficulties arise. It is estimated on such a basis that a loss of £5 per week would occur after disposal of the sludge as a manure at 30s. per ton.

In the foregoing estimates allowance is only made for the daily attendance of one man at £1 per week. In my opinion a higher skilled man would be required. The working of the process certainly does not require great training, but I could not expect the requisite amount of intelligence, and faithful work from an ordinary labourer. The simplicity of the process I admit, but its efficiency depends entirely on the regularity of the attention it requires. My experience of such works is, that unless they are entrusted to the best servants, well supervised, they are left to look after themselves, and become worse than useless.

For the protection of the riparian proprietors extra watchers would be required to act on their behalf, and I do not think this could be accomplished with less than three men, acting with considerable authority, and devoting their whole time to the work. They should have the power to return the effluent for re-treatment if it be found impure at the time of inspection. Two great difficulties are here met with, namely, the enormous volume of liquid to be returned, and the difficulty in telling the purity of the effluent without chemical analysis. Much polluting matter might be passing away in a practically clear liquid.

I have already expressed the opinion that a solution to the question of the disposal of distillery refuse is most likely to be found in a process which will turn the waste to some useful purpose, and unfortunately this is probably the line which has been most neglected in this country. Attempts have been made to dispose of the burnt ale as a liquid cattle food, and also as a liquid manure, but neither method I think can claim to be a success. The material is of such a sloppy, fermentable, and unmanageable nature that it cannot be readily disposed of in its original condition, but must first be concentrated.

Evaporating plant has been introduced into several of the distilleries, and has undoubtedly removed a considerable proportion of the very gross pollution which previously existed. The general tendency has been to produce a solid residue, suitable for manure, by the destruction of a considerable proportion of the organic constituents of the ale. I have examined several samples of the manure prepared in this manner, and I estimate the value to the consumer at about £4 15s. per ton. On Table C will be found three analyses of the manure which fairly represent its general quality and value. I understand that in some instances £5 per ton is got for it, carriage paid. While this method of disposal is in the right direction it entails a considerable and needless waste of the valuable organic constituents which are useful as a food.

I have calculated, that if the twenty-eight Speyside distilleries were in full operation, over 3,900 tons of good concentrated cattle food could be prepared per season of forty weeks working, of a monetary value of over £19,500. Such a sum appears to form a strong argument against the destruction of the ale by bacterial methods, with all the attendant uncertainty of obtaining an effluent that will meet the standard of purity which it has been established the riparian proprietors are entitled to claim.

The manufacture of cattle food from burnt ale has been fully considered in America, and this and other methods of disposal of distillery waste have formed the subject of special investigation by the United States Geological Survey, and the Ohio State Board of Health. The result of these investigations, and of practical trials on a fairly extensive scale, employing modern evaporating and drying plant, has fully established that the burnt ale can be manipulated to form a useful food, and return a substantial profit. The question of profit is entirely dependent on the quantity treated, as the efficiency of modern evaporating and drying plant depends entirely on its power of dealing with large quantities at a minimum cost for fuel and labour. Since the installation of the plant in America, attention to many details has led to increased profits, and further increase is expected. At the present time it is calculated that the expenses are equal to two-ninths of the value of the food produced.

I have made numerous calculations as to the cost of producing a food from the ale, and find, that even in a small distillery working 900 bushels per week a profit can be made. As the quantity to be treated increases, the profits rapidly rise, and it would therefore be advisable to establish one evaporating plant for a group of distilleries, where this was possible. The profits mentioned refer to the value of the food obtained after deducting the working expenses, and do not include interest on capital, nor is any allowance made for depreciation and upkeep.

The initial cost of evaporating plant is considerable, and on Tables D and E will be found a few particulars which I have obtained from The Mirrlees Watson Co., Ltd., Glasgow, as to the cost of evaporators which would be required to treat the waste from distilleries of different capacities.

The cost of the plant required to manipulate the concentrated liquor from the evaporator to form a marketable food is also high, but as the process has never been worked in this country I have been unable to obtain details. I gather, however, from American information, that this part of the plant will approach the cost of the evaporator. I can hardly credit this, but there is no doubt the cost would be considerable.

The advantage to be gained from manufacturing a feeding material, instead of a manure, is in the larger yield obtained, and a somewhat higher market value. There is also less likelihood of the question of atmospheric pollution being raised.

In arriving at the foregoing conclusions I have purposely considered a low figure in regard to quantity, and a reasonable price for the product, and I have made a very liberal allowance for wages and expenses. I would not be surprised to find that my figures are very far from the truth within a reasonable time from the starting of such a method of treatment. Past experience in the treatment of waste manufacturing products has shown, that what was originally considered a useless and expensive burden, has turned out a substantial profit earner.

So far consideration has only been given to the burnt ale, as it is the one liquid from which a profit may be expected. Unfortunately, the burnt ale only accounts for a limited quantity of the polluting liquors produced in a distillery, somewhat less than one-third. When the expense of evaporating what may be termed the useless liquids is taken into consideration, the profits from the ale evaporation rapidly become absorbed, as little return is obtained except from the ale.

The advantages and disadvantages of evaporation, properly conducted are :—

Advantages :—

Concentration of the plant, and non-liability of its efficiency being impaired under varying weather conditions.

No increase in quantity of the liquid to be treated, as no dilution is required.

An effluent of nearly pure water, which may be re-used within the distillery.

Concentration of the valuable constituents of the refuse to form a useful and marketable article.

A considerable monetary return, which in the meantime may be considered sufficient to pay most of the working expenses, and which may ultimately be expected to return a profit.

Valuable machinery which will speedily deteriorate unless it is regularly attended to.

From consideration of the return to be derived, a strong inducement for the distiller to faithfully work the plant.

Disadvantages :—

Preliminary cost of machinery, and doubtful economy in operating small quantities.

Regarding the quality of the effluent obtained it should theoretically be pure distilled water, but this is not the case, and analytical results have shown that the discharge may vary considerably in regard to its organic purity, and that it may contain free acidity, and compounds of iron. The results stated on Table F, are those obtained from samples of the effluent from Rothes Evaporation Works. Numbers 1 and 2 are of the discharge as it was leaving the works, and the evaporator effluent proper is mixed with the condensing water, so that the results are below the truth. The amount of condensing water may vary enormously, and generally no record is kept of it. The quantity required in actual working is seven times the volume of the liquid condensed, but I understand that as much as thirty volumes are frequently used. I am, therefore, unable to correct the figures in analyses 1 and 2, Table F, as no account can be got of the condensing water used.

For the purposes of this report I requested Supt. Macgregor to obtain a sample of the effluent unmixed with the condensing water, and this he was able to do. The results obtained from this sample are stated on Table F. under number 3. The liquid had a slight blae appearance, and a slight distillery odour. Since the sample was received it has developed a somewhat stronger odour, and it has shown a slight tendency towards decomposition.

I have consulted analyses, made by others, of the effluent from another evaporator, and the results agree generally with the Rothes figures, but there is considerable variation.

For a number of years I have had similar evaporators under my charge, and I have made frequent analyses of the effluents. The evaporators referred to are used for the concentration of waste esparto liquors, which are highly polluting, and somewhat troubleseme to treat. The working of the Rothes evaporator compares very favourably with the results I have observed from the treatment of soda liquors, and I am of opinion that the works at Rothes are tended with due care, and that the effluent is of the quality which may be expected from the evaporation of burnt ale on a full every day working scale.

Though the discharge cannot be considered pure, it is of a high standard, and it has this advantage that it has been thoroughly sterilised by being first converted into steam. A disadvantage, however, exists in the liquid being practically devoid of oxygen. If this was found to be an objection it could be largely overcome by a simple process of aeration.

Compared with the results obtained by the Coleburn Filtration System, the organic purity of the evaporator effluent is in every case much higher than even the diluted filtration effluent. The total solid residue bears no comparison, and the absence of nitric acid, and phosphoric acid compounds is a distinct advantage. The quantity of effluent obtained by evaporation is infinitely less, as not only is there no dilution, but a considerable proportion of liquid is vaporised in the drying of the concentrated liquid from the evaporator during the process of manipulating it as a manure, or feeding material.

Reference has been made to the admixture of the discharge proper with the condensing water. This is entirely dependent on the form of condenser employed. The evaporators are usually fitted with a "spray condenser," the only object of which appears to be that the discharge is diluted, and presents a better appearance than it is entitled to. If the evaporator is fitted with a "surface condenser," the actual discharge can be kept separate from the condensing water, and its true merits can be ascertained. As there is no advantage or disadvantage, as far as the working of the evaporator is concerned, in the one form of condenser or the other, preference should be given to the surface condenser.

If the effluent is ultimately to be discharged to the stream, it should first be received in a sufficiently large inspection tank, from which samples could be drawn at any time. Provision should be made whereby the contents of the tank could be returned to the evaporator if they were found in a condition unfit for discharge. With all evaporators there is a certain tendency to frothing, and occasionally a boil-over may take place. If such should happen the liquor would be caught in the inspection tank and returned.

Under the filtration process reference was made to the want of a ready test by which an inspector could determine whether the effluent was of a quality to be discharged. This also applies to the evaporator effluent. To overcome this difficulty, I would suggest that the evaporator effluent proper should be received in ponds, and re-used for feeding the steam boilers, and for the other requirements of the distillery. I see no reason why the whole of the water should not continuously circulate within the distillery, and be re-used time after time. With proper working the quality of the water need not be feared, and certainly if it is not produced of a quality fit for use in the distillery, it cannot be suitable for discharge.

After very careful consideration of all the information I have been able to obtain, and from my personal observations, I am of opinion that the quality of effluent, if effluent there is to be, which the riparian proprietors require, can only be obtained by a process of evaporation. A more complete protection against the pollution of the streams would undoubtedly be afforded by the constant re-use of the waters within the distillery, and this is not impracticable. The absence of any communication with the stream also removes any temptation to discharge undue polluting liquids at a time when their detection would be difficult, or impossible.

(Signed) STEVENSON MACADAM.

Messrs. John C. Brodie & Sons,
W. S.,
5, Thistle Street, Edinburgh.

EXPERIMENTAL WORKS OF ROYAL COMMISSION ON SEWAGE DISPOSAL AT COLEBURN DISTILLERY.

TABLE A.

Analysis of Samples collected on June 3rd, 1908.

—	1. Sample of Crude Liquor from Burnt Ale Tank before Treatment.	2. Burnt Ale Diluted Lime Treated and Settled.	3. Effluent from Percolating Filter before passing to Sand Filter.	4. Effluent from Sand Filter as passing to Hatchery.	5. Dam Water as entering Diluting and Mixing Tank.
Grains in Imperial Gallon :—	Grains.	Grains.	Grains.	Grains.	Grains.
Saline matter - - - - -	234·88	32·32	39·52	26·40	5·92
Organic and volatile matter -	1,028·16	41·60	28·64	7·52	1·36
Total solid matter - -	1,263·04	73·92	68·16	33·92	7·28
Nitrates and nitrites calculated as calcium nitrate - -	Absent.	Absent.	8·52	8·34	0·09
Chlorine - - - - - -	12·77	1·93	2·90	2·70	1·50
Phosphoric anhydride - -	81·71	7·78	5·42	1·38	Absent.
In million parts :—	Parts.	Parts.	Parts.	Parts.	Parts.
Free and saline ammonia - -	68·400	16·000	2·000	0·200	0·004
Albuminoid ammonia - -	117·200	27·600	11·550	1·720	0·210

(Signed) STEVENSON MACADAM.

TABLE B.

Analyses of Samples of Effluent received 1906–1907.

—	Fully Treated Effluent sampled December, 1906.	Treated Effluent sampled 5 p.m. March 14th, 1907.	Treated Effluent sampled April 12th, 1907.
Grains in Imperial Gallon :—	Grains.	Grains.	Grains.
Saline matter - - - - - - -	32·20	35·35	35·20
Organic and volatile matter - - - - - -	10·85	11·55	7·76
Total solid matter - - - - - -	43·05	46·90	42·96
Nitrates and nitrites calculated as calcium nitrate	0·74	3·19	4·67
Chlorine - - - - - - - - - -	4·10	3·60	3·20
Phosphoric anhydride - - - - - - -	—	1·56	0·46
In million parts :—	Parts.	Parts.	Parts.
Free and saline ammonia - - - - -	1·815	4·000	0·200
Albuminoid ammonia - - - - - -	2·325	3·060	1·470

(Signed) STEVENSON MACADAM.

TABLE C.

Analyses of Manure produced from Burnt Ale by Evaporation and Charring.

—	Tamdhu Distillery in Black Powder.	Rothes Evaporation Works Charred Cake before grinding.	Rothes Evaporation Works Charred Cake ground to powder.
	Per cent.	Per cent,	Per cent.
Nitrogen	5·46	5·04	5·00
Equal to Ammonia	6·64	6·12	6·08
Soluble Phosphates	3·79	4·79	5·13
Insoluble Phosphates	3·45	0·44	0·66
Insoluble Matter	0·53	0·42	0·46
Potash	5·22	4·27	4·41
Equal to Sulphate of Potash	9·65	7·89	8·15
Moisture	5·86	11·84	7·20
Organic Matter	80·78	76·76	80·70
Value by Highland and Agricultural Societies' Standards, 1908, as a mixed manure	£. s. d. 4 15 7 per ton.	£. s. d. 4 5 6 per ton.	£. s. d. 4 6 8 per ton.

Bags are allowed for at the rate of 5s. per ton.

(Signed) STEVENSON MACADAM.

TABLE D.

Evaporation of Burnt Ale alone.

Size and cost of evaporators required for concentration of burnt ale produced in distilleries of various capacities. The prices are for plant complete with all necessary boilers, engines, pumps, connections, foam preventers, liquor heaters, firing tools, &c., but do not include buildings, founds or underground drains, ale tanks, boiler seatings or chimneys :—

—	Distillery Capacity 4,500 bushels per week.	Distillery Capacity 900 bushels per week.	Distillery Capacity 1,000 bushels per week.
Working hours per week	72 hours.	72 hours.	72 hours.
Evaporator	Quintuple Effet	Quintuple Effet	Quintuple Effet
Heating surface	2,570 square feet.	520 square feet.	570 square feet.
Cost with jet condenser	£3,190	£1,545	£1,602
Cost with surface condenser	£16 less.	£18 less.	£18 less.
Depreciation	10 per cent.	10 per cent.	10 per cent.
Repairs and upkeep	5 ,, ,,	5 ,, ,,	5 ,, ,,

Guaranteed efficiency :—1 lb. good Scotch Splint Coal to evaporate 20 lbs. of water from ale.

(Signed) STEVENSON MACADAM.

TABLE E.

Evaporation of all Distillery Wastes.

Size and cost of evaporators required for concentration of all waste liquors produced in distilleries of various capacities. The prices are for plant complete with all necessary boilers, engines, pumps, connections, foam preventers, liquor heaters, firing tools, &c., but do not include buildings, founds or underground drains, ale tanks, boiler seatings or chimneys.

——	Distillery Capacity 4,500 bushels per week.	Distillery Capacity 900 bushels per week.	Distillery Capacity 1,000 bushels per week.
Working hours per week	144 hours	144 hours	144 hours
Evaporator	Quintuple Effet	Quintuple Effet	Quintuple Effet
Heating surface	4,950 square feet	1,000 square feet	1,100 square feet
Cost with jet condenser	£4,888	£2,247	£2,370
Cost with surface condenser	£40 less	Same price	Same price
Depreciation	10 per cent.	10 per cent.	10 per cent.
Repairs and upkeep	5 „ „	5 „ „	5 „ „

Guaranteed Efficiency :—1 lb. good Scotch Splint Coal to evaporate 20 lbs. of water.

(Signed) Stevenson Macadam.

TABLE F.

ROTHES EVAPORATION WORKS.

Analyses of Samples of Evaporator Discharge.

——	1. Discharge from Evaporation Works 1 p.m. 8th February, 1906. Mixed with Condensing Water.	2. Discharge from Evaporation Works. April, 1907. Mixed with Condensing Water.	3. Pure Discharge Evaporator 5 p.m. 17th June, 1908. Unmixed with Condensing Water.
Grains in Imperial Gallon :—	Grains.	Grains.	Grains.
Saline matter	4·32	4·08	4·32*
Organic and volatile matter	4·16	2·56	4·24
Total solid matter	8·48	6·65	8·56
Nitrates and nitrites	Absent.	Absent.	Absent.
Chlorine	1·50	1·60	0·20
Phosphoric anhydride	?	?	?
Acidity as acetic acid	—	Faintly Acid.	23·40
In million parts :—	Parts.	Parts.	Parts.
Free and saline ammonia	0·028	0·060	0·200
Albuminoid ammonia	0·288	0·256	0·260

* Containing Iron equal to ferric oxide 0·848 grains per gallon.

(Signed) Stevenson Macadam.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

SEVENTH REPORT

OF

THE COMMISSIONERS

APPOINTED TO INQUIRE AND REPORT WHAT METHODS OF

Treating and Disposing of Sewage

(Including any Liquid from any Factory or Manufacturing Process)

MAY PROPERLY BE ADOPTED.

Nuisances due to excessive growths of Green Sea-weeds in Sewage Polluted Estuaries, with special reference to Belfast Lough.

VOL. I.—REPORT.

Presented to both Houses of Parliament by Command of His Majesty.

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November 1911

VICTORIA R.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith: To Our Right Trusty and Right Well-beloved Cousin, Walter Stafford, Earl of Iddesleigh, Companion of Our Most Honourable Order of the Bath; Our Trusty and Well-beloved Sir Richard Thorne Thorne, Knight Commander of Our Most Honourable Order of the Bath, Medical Officer of the Local Government Board; Our Trusty and Well-beloved Constantine Phipps Carey, Esquire, Lieutenant-Colonel and Honorary Major-General on the Retired List of Our Army; Our Trusty and Well-beloved Charles Philip Cotton, Esquire; Our Trusty and Well-beloved Michael Foster, Esquire, Master of Arts, Professor of Physiology in Our University of Cambridge; Our Trusty and Well-beloved Thomas Walter Harding, Esquire, Retired Lieutenant-Colonel of Our Auxiliary Forces, with Honorary Rank of Colonel; Our Trusty and Well-beloved Thomas William Killick, Esquire; Our Trusty and Well-beloved William Ramsay, Esquire, Professor of Chemistry, University College, London; and Our Trusty and Well-beloved James Burn Russell, Esquire, Doctor of Medicine, Master of Surgery: Greeting!

Whereas We have deemed it expedient that a Commission should forthwith issue to inquire and report:

1. (1) What method or methods of treating and disposing of sewage (including any liquid from any factory, or manufacturing process) may properly be adopted, consistently with due regard for the requirements of the existing law, for the protection of the public health, and for the economical and efficient discharge of the duties of local authorities; and

(2) If more than one method may be so adopted, by what rules, in relation to the nature or volume of sewage, or the population to be served, or other varying circumstances or requirements, should the particular method of treatment and disposal to be adopted be determined; and

2. To make any recommendations which may be deemed desirable with reference to the treatment and disposal of sewage;

Now know ye, that We, reposing great trust and confidence in your knowledge and ability, have authorised and appointed, and do by these Presents authorise and appoint, you, the said Walter Stafford, Earl of Iddesleigh, Sir Richard Thorne Thorne, Constantine Phipps Carey, Charles Philip Cotton, Michael Foster, Thomas Walter Harding, Thomas William Killick, William Ramsay, and James Burn Russell to be Our Commissioners for the purposes of the said Inquiry.

And, for the better effecting the purposes of this, Our Commission, We do by these Presents give and grant unto you, or any three or more of you, full power to call before you such persons as you shall judge likely to afford you any information upon the subject of this Our Commission; and also to call for, have access to, and examine all such books, documents, registers, and records as may afford you the fullest information on the subject, and to inquire of and concerning the premises by all other lawful ways and means whatsoever.

And We do by these Presents authorise and empower you, or any three or more of you, to visit and personally inspect such places as you may deem it expedient so to inspect for the more effectual carrying out of the purposes aforesaid.

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And We do further by these Presents will and ordain that this Our Commission shall continue in full force and virtue, and that you, Our said Commissioners, or any three or more of you, may from time to time proceed in the execution thereof, and of every matter and thing therein contained, although the same be not continued from time to time by adjournment.

And We do further ordain that you, or any three or more of you, have liberty to report your proceedings under this Our Commission from time to time, if you shall judge it expedient so to do.

And Our further Will and Pleasure is that you do, with as little delay as possible, report to Us, under your hands and seals, or under the hands and seals of any three or more of you, your opinion upon the matters herein submitted for your consideration.

And for the purpose of aiding you in such matters, We hereby appoint Our Trusty and Well-beloved Frederick James Willis, Esquire, to be Secretary to this Our Commission.

Given at our Court at St. James's, the Seventh day of May, One thousand eight hundred and ninety-eight, in the Sixty-first Year of Our Reign.

By Her Majesty's Command,
(Signed) M. W. Ridley.

William Henry Power, Esq., f.r.s.,
To be a Member of the Royal Commission on Sewage Disposal.

VICTORIA R.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith: To Our Right Trusty and Well-beloved William Henry Power, Esquire, Fellow of the Royal Society, Medical Officer of the Local Government Board: Greeting!

Whereas We did, by Warrant under Our Royal Sign Manual, bearing date the Seventh day of May, One thousand eight hundred and ninety-eight, appoint Our Right Trusty and Right Well-beloved cousin Walter Stafford, Earl of Iddesleigh, Companion of Our Most Honourable Order of the Bath, together with the several Gentlemen therein mentioned, or any three or more of them, to inquire into the treatment and disposal of sewage.

And whereas One of the Commissioners so appointed, namely, Sir Richard Thorne Thorne, has since deceased.

Now know ye, that We, reposing great confidence in you, do, by these Presents, appoint you, the said William Henry Power, to be one of Our Commissioners for the purpose aforesaid, in the room of the said Sir Richard Thorne Thorne, deceased, in addition to, and together with, the other Commissioners whom we have already appointed.

Given at our Court at Saint James's, the Seventh day of February, One thousand nine hundred, in the Sixty-third Year of Our Reign.

By Her Majesty's Command,
(Signed) M. W. Ridley.

Whitehall, March 18th, 1901.

THE KING has been pleased to issue a Commission, under His Majesty's Royal Sign Manual, to the following effect :—

EDWARD R.

Edward the Seventh, by the Grace of God, of the United Kingdom of Great Britain and Ireland King, Defender of the Faith, to all to whom these Presents shall come, Greeting !

Whereas it pleased Her late Majesty from time to time to issue Royal Commissions of Inquiry for various purposes therein specified :

And whereas, in the case of certain of these Commissions, namely, those known as—

The Historical Manuscripts Commission ;
The Horse Breeding Commission ;
The Local Taxation Commission ;
The Port of London Commission ;
The Salmon Fisheries Commission ; and
The Sewage Disposal Commission ;

the Commissioners appointed by Her late Majesty, or such of them as were then acting as Commissioners, were, at the late demise of the Crown, still engaged upon the business entrusted to them :

And whereas, We deem it expedient that the said Commissioners should continue their labours in connection with the said enquiries notwithstanding the late demise of the Crown :

Now know ye, that We, reposing great trust and confidence in the zeal, discretion, and ability of the present members of each of the said Commissions, do by these Presents authorise them to continue their labours, and do hereby in every essential particular ratify and confirm the terms of the said several Commissions.

And We do further ordain that the said Commissions do report to Us under their hands and seals, or under the hands and seals of such of their number as may be specified in the said Commissions respectively, their opinion upon the matters presented for their consideration ; and that any proceedings which they or any of them may have taken under and in pursuance of the said Commissions since the late demise of the Crown, and before the issue of these Presents shall be deemed and adjudged to have been taken under and in virtue of this Our Commission.

Given at Our Court at Saint James's, the fourth
day of March, One thousand nine hundred and one,
in the First Year of Our Reign.

By His Majesty's Command,
(Signed) CHAS. T. RITCHIE.

THOMAS JOSEPH STAFFORD, F.R.C.S.I.,
To be a Member of the Royal Commission on Sewage Disposal.

EDWARD R.

Edward the Seventh, by the Grace of God, of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas King, Defender of the Faith. To Our Trusty and Well-beloved Thomas Joseph Stafford, Esquire, Fellow of the Royal College of Surgeons of Ireland, Medical Commissioner of the Local Government Board for Ireland : Greeting !

Whereas Her late Majesty Queen Victoria did by Warrant under the Royal Sign Manual bearing date the Seventh Day of May One thousand eight hundred and nineth-eight, appoint Our Right Trusty and Right Well-beloved Cousin, Walter Stafford, Earl of Iddesleigh, Companion of Our Most Honourable Order of the Bath, together with the several Gentlemen therein mentioned, to be Commissioners to inquire into the treatment and disposal of Sewage.

And whereas, one of the Commissioners so appointed, namely, Our Trusty and Well-beloved Charles Philip Cotton, Esquire, hath humbly tendered unto Us his resignation of his appointment as one of the said Commissioners :

Now know ye, that We, reposing great confidence in you, do by these Presents appoint you, the said Thomas Joseph Stafford, to be one of Our Commissioners for the purpose aforesaid, in the room of the said Charles Philip Cotton, resigned, in addition to and together with the present Members of the Commission.

Given at Our Court at Saint James's, the Seventh day of May, One thousand nine hundred and two, in the Second Year of Our Reign.

By His Majesty's Command,
(Signed) CHAS. T. RITCHIE.

REGINALD ARTHUR TATTON, ESQUIRE,
To be a Member of the Royal Commission on Sewage Disposal.

EDWARD R. & I.

Edward the Seventh, by the Grace of God, of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas King, Defender of the Faith, To Our Trusty and Well-beloved Reginald Arthur Tatton, Esquire, Greeting !

Whereas Her late Majesty Queen Victoria did by Warrant under the Royal Sign Manual bearing date the Seventh Day of May, One thousand eight hundred and ninety-eight, appoint Commissioners to inquire into the treatment and disposal of Sewage.

And whereas, a vacancy has been caused in the body of the Commissioners appointed as aforesaid by the death of Major-General Constantine Phipps Carey, C.B.

Now know ye, that We, reposing great confidence in you, do by these Presents appoint you, the said Reginald Arthur Tatton, to be one of Our Commissioners for the purpose aforesaid, in the room of the said Constantine Phipps Carey, deceased, in addition to and together with the present Members of the Commission.

Given at Our Court at Saint James's, the Seventh day of January, One thousand nine hundred and seven, in the Sixth Year of Our Reign.

By His Majesty's Command,
(Signed) H. J. GLADSTONE.

Whitehall, May 30th, 1910.

The King has been pleased to issue a Warrant under His Majesty's Royal Sign Manual to the following effect :—

GEORGE R. & I.

George the Fifth, by the Grace of God, of the United Kingdom of Great Britain and Ireland, and of the British Dominions beyond the Seas King, Defender of the Faith, to all to whom these Presents shall come. Greeting !

Whereas it pleased His late Majesty from time to time to issue Royal Commissions of Inquiry for various purposes therein specified :

And whereas, in the case of certain of these Commissions, namely, those known as—

The Historical Manuscripts Commission ;
The Horse Breeding Commission ;
The Sewage Disposal Commission ;
The Poor Laws Commission ;
The Tuberculosis Commission ;
The Canal Communication Commission ;
The Mines Commission ;
The Welsh Church Commission ;
The Coast Erosion and Afforestation Commission ;
The Vivisection Commission ;
The Land Transfer Acts Commission ;
The Ancient Monuments (Wales and Monmouthshire) Commission ;
The Ancient Monuments (England) Commission ;
The Trade Relations between Canada and the West Indies Commission ;
The Selection of Justices of the Peace Commission ;
The Divorce and Matrimonial Causes Commission ;
The University Education in London Commission ; and
The Brussels, Rome and Turin Exhibitions Commission ;

the Commissioners appointed by His late Majesty, or such of them as were then acting as Commissioners, were at the late demise of the Crown, still engaged upon the business entrusted to them :

And whereas, We deem it expedient that the said Commissioners should continue their labours in connection with the said enquiries notwithstanding the late demise of the Crown :

Now know ye, that We, reposing great trust and confidence in the zeal, discretion, and ability, of the present members of each of the said Commissions, do by these Presents authorise them to continue their labours, and do hereby in every essential particular ratify and confirm the terms of the said several Commissions.

And We do further ordain that the said Commissioners do report to Us under their hands and seals, or under the hands and seals of such of their number as may be specified in the said Commissions respectively, their opinion upon the matters presented for their consideration ; and that any proceedings which they or any of them may have taken under and in pursuance of the said Commissions since the late demise of the Crown and, before the issue of these Presents shall be deemed and adjudged to have been taken under and in virtue of this Our Commission.

Given at Our Court at Saint James's, the twenty-sixth day of May, One thousand nine hundred and ten, in the First Year of Our Reign.

By His Majesty's Command,
(Signed) R. B. Haldane.

FREDERICK JAMES WILLIS, ESQ.,
To be a Member of the Royal Commission on Sewage Disposal.

GEORGE R. & I.

George the Fifth, by the Grace of God, of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas King, Defender of the Faith: To Our Trusty and Well-beloved Frederick James Willis, Esquire, Barrister-at-law, one of the Assistant Secretaries to the Local Government Board. Greeting!

Whereas Her late Majesty Queen Victoria did by Warrant under the Royal Sign Manual bearing date the Seventh day of May, One thousand eight hundred and ninety eight, appoint Commissioners to inquire into the treatment and disposal of Sewage:

Now know ye, that We, reposing great confidence in you do by these Presents appoint you the said Frederick James Willis, sometime Secretary to the said Royal Commission, to be an additional Commissioner for the purposes aforesaid.

Given at Our Court at Saint James's the Twentieth day of July, One thousand nine hundred and ten, in the First Year of Our Reign.

By His Majesty's Command,
(Signed) W. S. CHURCHILL.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

SEVENTH REPORT.

To The King's Most Excellent Majesty:

May it Please Your Majesty:

We, your Commissioners, appointed to inquire into the methods of disposing of sewage and trade effluents, humbly submit this Report concerning the association of sewage pollution in tidal waters with excessive growth of green sea weeds.

I.—INTRODUCTORY.

1. At the conclusion of our Fifth Report we stated that the remainder of our inquiries would be chiefly concerned with the disposal of trade effluents when not mixed with sewage, and that we should also continue our observations on the effect of discharging sewage effluents of known composition into streams, with a view to reporting more fully on the question of standards and tests. These subjects are still under investigation, and we are not at present in a position to report definitely upon them.

2. Since the issue of our Fifth Report we have been invited to investigate the question of nuisance, and possible damage to health, which is caused by decaying sea weeds, whose superabundant growth has been freely attributed to the stimulating effects of a mixture of sewage and sea water. The case of Belfast Lough was in this connection specially referred to us by the Local Government Board for Ireland, and as the matter was urgent we decided to take up the investigation concurrently with our other work. We are now in a position to report on this subject, and we think it desirable to treat the question separately, without waiting for the completion of our other investigations.

3. The disadvantage arising from the growth of green seaweed in estuaries was first brought to our notice by Professor Letts, who gave evidence before us in 1902 in connection with our inquiry into the pollution of tidal waters. He described the nuisance caused by decaying masses of the weed known as *Ulva latissima* (or Sea lettuce). The nuisance was, he represented, most serious on the shores of Belfast Lough, though found in lesser degree in other places, such as Dublin Harbour. Professor Letts then expressed the opinion that the superabundant growth of *Ulva* was intimately associated with the pollution of sea water by sewage. Letts, 8574.

4. We did not, however, take up the direct investigation of this question until 1909, when our attention was called to the subject by the Local Government Board for Ireland in connection with a scheme for the treatment of the sewage of Belfast, designed with a view to diminishing or suppressing the growth of *Ulva* in the Lough. The terms of the letter of the Local Government Board and of our reply were as follows:—

Local Government Board, Dublin.
March 22nd, 1909.

Sir,—

I am directed by the Local Government Board for Ireland to acquaint you, for the information of the Royal Commission on Sewage Disposal, that the Board have received an application from the Corporation of Belfast for sanction to a loan of £112,300 for sewage purification works, of which it is proposed to devote £80,780 to the main outfall works and £31,520 to the completion of the Sydenham and Knock drainage scheme.

The Board forward extracts from a Report received by them showing the proposals of the Corporation, and, as the Board observe from the Fifth Report of the Royal Commission that the Royal Commission is familiar with the conditions of Belfast Lough, they would be glad to know whether the Commission would be so good as to advise the Board . . . whether the Royal Commission propose to investigate further the conditions under which green growths associated with sewage disposal in estuaries such as Belfast Lough are encouraged, and the best and least expensive means of treating sewage so as to avoid the nuisance caused by such growths upon the foreshores of estuaries.

I am, Sir,
Your obedient Servant,
(*Signed*) A. R. BARLAS,
Secretary.

The Secretary,
Royal Commission on Sewage Disposal,
5, Old Palace Yard, Westminster, S.W

Royal Commission on Sewage Disposal,
5, Old Palace Yard, S.W.
June 11*th*, 1909.

Sir,—

I am directed by the Royal Commission to advert to your letter of March 22nd last, inquiring whether the Commission propose to investigate further the conditions under which green growths associated with sewage disposal in estuaries, such as Belfast Lough, are encouraged, and the best and least expensive means of treating sewage so as to avoid the nuisance caused by such growths upon the foreshores of estuaries.

The case to which the Local Government Board draw special attention is that of Belfast Lough where, undoubtedly, a serious nuisance is, at times, experienced. From inquiries which the Commission have made it appears that a similar nuisance, though of less extent, has been experienced in other localities.

Apart, however, from the valuable work which has been carried out by Professor Letts at Belfast, the Commission are not aware that any systematic investigations have been made with a view to determining under what conditions the nuisance arises and how it can best be remedied, and even in the case of Belfast the investigations do not appear to the Commission to have been sufficiently extended to justify final opinions being formed.

The questions involved present considerable difficulties, and it is probable that they differ, at any rate to some extent, in different cases; but after careful consideration the Commission have arrived at the conclusion that the matter is of sufficient general importance to justify them in making some inquiries in regard to it.

Looking to the work which has already been done by Professor Letts the Commission think that the case of Belfast Lough should be first investigated, but before coming to a definite decision in the matter they would wish to learn whether the Corporation of Belfast are willing to render the Officers of the Commission such assistance as may be necessary.

The Commission would suggest that in the first instance the Local Government Board should ascertain the views of the Corporation of Belfast in regard to this suggestion.

I am, Sir,
Your obedient Servant,
(*Signed*) F. J. WILLIS,
Secretary.

The Local Government Board for Ireland subsequently informed us that the Corporation were willing to assist us in every way, and we therefore decided to make a careful study of the conditions of Belfast Lough in regard to the nuisance complained of. Throughout our inquiry the Belfast Corporation have granted us every facility to pursue our investigations.

II.—HISTORY OF *ULVA* NUISANCE IN BELFAST LOUGH.

5. It may be convenient shortly to review the history of the problem at Belfast, and the considerations which led us to the conclusion that the relation of *Ulva* to sewage pollution was such as clearly to bring an inquiry into the subject within the terms of our reference.

For a number of years prior to the date of our inquiry a very serious nuisance had been experienced round the shores of Belfast Lough. It was at one time contended that the offensive smell which was complained of was due to the actual deposit of sewage matter upon the extensive sloblands of the Lough. That view, however, has now been abandoned by most of the complainants in favour of the theory that the pollution of the Lough promotes the excessive growth of green seaweeds (principally *Ulva latissima*), which when they decay on the shore give off large quantities of sulphuretted hydrogen, and so cause nuisance.

Before discussing in detail the validity of this theory we may indicate the general grounds on which an association between the growth of *Ulva* and sewage pollution has been assumed.

6. It has been represented to us that the growth of this weed in Belfast Lough has varied more or less directly with the amount of sewage pollution. It has been asserted that some fifty or sixty years ago, when the sewage of the City, comparatively small in amount, was discharged into the Lagan, and reached the Lough in a condition of considerable dilution and deprived probably of the bulk of its suspended solids, the foreshores of the Lough and extensive mussel beds thereon were practically free from weed. It has also been pointed out that in consequence of the reconstruction of the Belfast system of sewerage between 1887 and 1893 crude sewage, in greater volume than before, was discharged nearer to the sloblands, and that concurrently with this a considerable increase of the *Ulva* nuisance was observed.

7. In 1893 a new main drainage system, authorised by the Belfast Main Drainage Act of 1887, was completed, the object of which was to discharge the bulk of the sewage directly into the Lough at a point prescribed by the Act between the navigation channel and the north shore.

For a time the sewage was discharged at this point through a wooden chute on the ebb tide into deep water, and it is alleged that so long as the chute remained intact the nuisance was less serious.

8. After a while, the chute became leaky, and liable through blockage to frequent bursts, the result of which was that sewage matter was discharged in the shallower waters of the Lough at all states of the tide, which in this part is so sluggish that very little of the polluting matter could, in the circumstances, be carried away to sea.

It has been very positively asserted that during this latter period the *Ulva* nuisance has again considerably increased upon the shores of the Lough.

9. In 1899 the connection between *Ulva* and sewage pollution at Belfast had become so generally accepted that by a provision of a local Act of that year the Corporation were required within three years from the passing of the Act to "provide works and appliances necessary for the proper purification of the sewage of the City of Belfast discharged from the system of works authorised by the Belfast Main Drainage Act, 1887."

With a view to meeting the obligations thus laid upon them by Statute, the Corporation sought the advice of Professor Letts, who carried out a series of experiments and inquiries, and proposed a carefully considered scheme for complete purification of the Belfast sewage.

10. In 1907 a Commission was appointed by the Local Government Board for Ireland to inquire into the public health of the City of Belfast and to make recommendations for its improvement. The Report of this Commission, published in the following year, threw doubt upon the wisdom of carrying out a complete scheme of sewage purification until it had been more conclusively proved that precautions in excess of sedimentation of the sewage were really required.

11. The Corporation decided to adopt the recommendation of the Health Commission to proceed first with the sedimentation of the sewage and the effective limitation of its discharge to the first three and a half hours of the ebb tide, and to defer the question of providing additional means of purification for further consideration.

This recommendation, and the decision of the Corporation to adopt it, aroused considerable opposition from local authorities and owners on the foreshores outside the City. They regarded the decision as an attempt on the part of the Corporation to evade their statutory obligations.

12. Eventually, the question of the relation of sewage pollution to the growth of *Ulva* was, at the instance of the Local Government Board for Ireland, commended to us for investigation; and, as stated by us in our letter to that Board, we considered that the question was one of sufficient general importance to warrant our making inquiries in regard to it. We believed that an investigation of the conditions of Belfast Lough might prove of value in the solution of similar difficulties arising in other localities.

III.—METHOD OF INVESTIGATION.

13. We instructed Mr. Frye, one of our chemists, and Mr. Kershaw, our engineer, to visit Belfast and other places and to carry out experiments and investigations as to the relations of *Ulva* and sewage. In these they had the co-operation of Professor Letts, whom we had appointed as a temporary officer of the Commission, and whose special knowledge of the question was of great value to us; of Mr. Richards, one of our assistant chemists; and of Mr. A. D. Cotton, whose services were placed at our disposal by the courtesy of the Director of the Royal Botanic Gardens, Kew, with a view to the investigation of the botanical aspects of the subject.

14. We recognised at an early stage that our inquiry must necessarily cover a wide field. It would embrace investigations into the life history of *Ulva latissima*, its embryology, its chemical composition and the conditions under which it thrives and decays, as well as any special conditions which have led to its luxuriant growth in particular localities, and the means which may be adopted for its destruction or utilisation.

The lines on which we instituted experiments and investigations may be summarised as follows :—

(*a*) Detailed surveys of the foreshores, sloblands and bed of Belfast Lough, and of the various points at which sewage was being or might be discharged.

(*b*) Float experiments in the Lough to ascertain the set and rate of the currents under different conditions of wind and tide.

(*c*) Dredging and trawling operations for discovering whether there was any mass of *Ulva* growing or decaying in deep water.

(*d*) Observation of the localities in Belfast Lough or elsewhere where *Ulva* was abundant with a view to discovering typical nurseries of the weed.

(*e*) Chemical analyses of the Lough water at various points and of the sewage discharging into it.

(*f*) Chemical analyses of the tissues of *Ulva* and other green weeds.

(*g*) Chemical and bacteriological analyses of muds and sludge found in different parts of the Lough.

(*h*) Comparative experiments on the growth of *Ulva* in sea water with and without the addition in differing amounts of fresh water or sewage or both.

(*i*) Inquiry into the fermentative changes in sea and in fresh water when polluted with sewage.

(*j*) Various experiments on the utilisation of *Ulva* for commercial purposes, *e.g.*, by drying for use as manure or by distilling for the production of sulphate of ammonia.

(*k*) Experiments on the effect on *Ulva* growth of removing mussels from *Ulva* banks.

(*l*) Experiments on the effect of the application of copper sulphate to the banks in destroying and preventing the growth of the weed.

(*m*) Inquiry into the botany of *Ulva* found in various localities.

15. In September, 1909, some of our number visited Belfast and spent some days in inspecting the Lough, the sloblands and the shores and in critically observing the experiments which were then in progress.

More recently some of us have visited the neighbourhood of Swanage, Studland, Poole and Weymouth, with a view to investigating the growth of *Ulva* in unpolluted or comparatively unpolluted waters.

16. Early in 1910 we decided to hear any evidence which parties interested in Belfast Lough might wish to tender. We invited a number of public bodies and riparian owners to send representatives or to attend for the purpose of giving evidence on the cause of the foreshore nuisance and the means to be adopted for avoiding it. Invitations were addressed to the Belfast Corporation, the Belfast Harbour Commissioners, the Castlereagh Rural District Council, the Holywood Urban District Council, the Belfast Foreshore Committee (representing ratepayers, residents and property owners on the shores of the Lough), and Mr. Henry Harrison, of Holywood, and Mr. R. J. Kennedy, of Cultra, riparian owners. Of this number the Castlereagh Council did not consider themselves in a position at that time to offer expert evidence which would be of material assistance to the Commission, while the Foreshore Committee and Mr. Kennedy, who had previously been signatories to a Petition praying to be allowed to submit their case to the Commission, finally decided that their interests might be prejudiced by their appearance for the purpose of giving evidence.

17. In February, 1910, we took the evidence of the following parties :—

30628–31133.	Mr. Henry Harrison and Mr. R. I. Calwell, C.E.	
31134–31455.	Alderman J. King Kerr, M.D., J.P. Councillor Crawford McCullagh Mr. H. A. Cutler, M. Inst. C.E. Mr. W. E. Adeney, D. Sc., F.I.C., F.C.S. Mr. John Hawthorne, B.A., Ph.D.	Representing the Belfast Corporation.
31456–31697.	Mr. Robert Thompson, M.P. Mr. W. Redfern Kelly, M.Inst.C.E.	Representing the Belfast Harbour Commissioners.
31698–31911.	Councillor George Murdoch Mr. David Bell	Representing the Holywood Urban District Council.

IV.—PHYSICAL ASSOCIATION OF *ULVA* WITH SEWAGE IN BELFAST LOUGH.

18. As will be seen from the plan* the upper or inner portion of the Lough is divided longitudinally by the Victoria Channel which now forms the outlet of the river Lagan and is prolonged into the main navigation channel. The Belfast main outfall works are situated on the Antrim side of this channel, and the chute, to which reference has been made, runs from the works for about a mile seaward, *i.e.*, in a direction parallel to that of the channel. Local sewage discharges of small volume occur on the County Down side, viz., from the Connswater river, Sydenham, Holywood Barracks, Holywood Town, etc., but the vast proportion of the sewage entering the Lough is delivered on the Antrim side of the Victoria Channel.

Chemical analyses indicate that in the upper part of the Lough, within a line drawn from Macedon Point to Holywood, the water is uniformly fouled with sewage to a degree corresponding to about 1 per cent. by volume of average Belfast sewage, as measured by the ammoniacal nitrogen. The exceptions to this degree of pollution occur in the

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* See Map at end.

Seal Channel and in the neighbourhood of the chute, where at certain states of the tide the pollution is on occasion very great indeed, and to a lesser extent in the Connswater Channel. Further, the chlorine figures show an admixture of fresh water over the greater portion of this area to an amount ranging between 19 per cent. in the winter and 10 per cent. in the summer.

19. There occurs, in certain areas of the Lough, a superabundant growth of green seaweeds, consisting mainly of *Ulva latissima,* with various species of *Enteromorpha* and *Monostroma.*

The weeds are to be found growing between the tide levels all round the inner Lough (from the City to Grey Point on the one shore and Carrickfergus on the other); but an exceptionally great development of *Ulva* occurs on the banks, between half tide and low water, on the County Down shore between the Kinnegar and the East Twin Island. This area may, we consider, be regarded as the main nursery of the weed. The nuisance from smell is experienced chiefly at Sydenham, Tillysburn, Holywood and Cultra on the County Down shore, but also to some extent on the Antrim side.

20. Evidence was tendered by some witnesses in support of the view that sewage solids, from the Belfast outfall can, under suitable conditions, be carried more or less directly on to the County Down foreshore, that a direct nuisance is thus caused, and that a superabundant growth of *Ulva* is thereby fostered. We may refer particularly to the evidence of Mr. Henry Harrison, Mr. Robert Thompson and Mr. George Murdoch.

21. Dr. Hawthorne and Mr. Cutler, on the other hand, were both of opinion that no considerable amount of solids suspended in sewage could find their way from the chute across the dredged channel to the County Down banks. The bulk of such sewage matter as was found on those banks was in their view probably brought down by the Lagan and Connswater rivers. On the Antrim side of the Lough where, they agreed, crude sewage had undoubtedly been discharged at times owing to the inefficiency of the chute, a direct nuisance due to actual sewage matter probably existed for a while in addition to the *Ulva* nuisance. But since the chute has been cleared and repaired and sedimentation of the sewage carried out no nuisance of this kind had been complained of on the Antrim shore.

22. Our comparative analyses of the mud on the *Ulva* banks and of sewage sludge go to discount the theory which would attribute the superabundant growth of the weed on the Down shore to sewage solids. Sulphur is an important constitutent of fresh *Ulva*—amounting to over 4 per cent. of the dried weed—and the high sulphur content of the mud on the Holywood and Connswater banks, compared with that of other samples of mud and of sewage sludge, indicates that these banks are largely composed of decayed *Ulva* and not of sewage solids. This inference is supported by a direct comparison of the physical character of the mud on these banks with that of the sewage deposit found in the neighbourhood of the chute.

Further, the float experiments carried out by our officers indicate that while it is possible that sewage matters floating in the water near the chute can, in some circumstances and probably after several days, be conveyed to the County Down shore, the main tendency of the tides in this neighbourhood is to carry suspended matters seawards.

23. We are, therefore, of opinion that the nuisance experienced in the neighbourhood of the County Down banks is not mainly caused by the deposit of sewage solids, and that the superabundant growth of *Ulva* can only to a very small extent, if at all, be due to the deposit of sewage solids. At the same time we think that it is necessary, in order to prevent the silting up of the navigable channels and the de-oxygenation of the water, that the sewage should be freed from the greater portion of its suspended solids before it is discharged into the Lough. No doubt, too, the partial purification which would be thus effected would diminish the number of micro-organisms of intestinal derivation in the sewage; but in our opinion it is not practicable by any process of sewage purification which might be adopted to ensure such a degree of bacteriological purity of the waters of the inner Lough as would render uncooked shell fish gathered from the sloblands safe articles of human food.

V.—OTHER PHYSICAL CONDITIONS AFFECTING THE GROWTH OF *ULVA*.

24. Further, the existence of liquid sewage pollution is not in itself a sufficient cause of a luxuriant growth of *Ulva.* We shall advert to this point later ; at this stage it will suffice to state that in Belfast Lough, although the pollution is fairly uniform, *Ulva* is found growing vigorously only in certain limited areas, and that we have found the weed in

quantity at Studland (Dorset) and other places where the sea water is free from sewage pollution. Our own observations and the testimony of various witnesses show conclusively that physical conditions other than a particular quality of the water are essential to the growth of the weed in any considerable quantity. The chief of these conditions are (1) sheltered and shallow waters with sluggish currents, and (2) the existence of means of anchorage for the weed.

25. As regards the first point, Belfast Lough and the estuary of the Thames below Crossness furnish an instructive contrast. At Crossness there is an enormous discharge of the precipitation liquor from London sewage, but no *Ulva* nuisance has been detected. On the other hand, some of the sloblands of Belfast Lough provide ideal conditions for the development of the weed. *Ulva* grows with a broad frond and by a very weak attachment. It is thus easily detached by the action of waves or currents, and though it is capable of continuing to grow when detached and while drifting, our experience shows that it reaches its greatest development when attached to some fixed anchorage. Our dredging operations disclosed no considerable quantity of *Ulva* rooted in deep water, and, as to the fronds caught during the trawling, their size and condition and the positions in which they were found, all indicated that they had drifted from the banks where great quantities of *Ulva* were growing. The areas on which *Ulva* was found by us growing in greatest abundance were banks which were uncovered at low tide and were sheltered from strong currents and rough water.

The Relation Between Mussels and *Ulva*.

Appendix IV.

26. The second condition, that of anchorage, is of even greater importance. For a full description of the mode of development of *Ulva* we may refer to Mr. Cotton's botanical report which is printed in the Appendix hereto ; but for our present purpose it is sufficient to emphasize the relation which mussel beds bear to the growth of the weed. The part which the mussel plays is two-fold. It affords, first, a solid support on which the *Ulva* spore can germinate and grow, and, second (as was first pointed out by Professor Letts) by the byssus threads which it throws out it will detain detached and drifting fronds and secure them against the action of the wind and tide, or it will attach itself to a growing frond, thus encouraging a new centre of growth by a process similar to layering.

27. In Belfast Lough we found that considerable areas of the sloblands are more or less thickly covered with mussel beds, which attain their greatest development at the mouth of the Connswater and on the outer half of the Tillysburn bank. On the Antrim shore the mussels are scattered and less numerous. Our officers found that *Ulva* fronds attached by their own roots to mussel shells were fairly common, but the number of these was insignificant compared with the number of fronds held by mussel threads. Mr. Cutler also gave evidence to this effect. In several places the weight of wet *Ulva* lying on the dense mussel banks was over 100 lbs. to the square yard of surface, and the total quantity growing on the banks was more than sufficient to account for the quantity of detached fronds cast up on the foreshores of both sides of the Lough. Cutler, 31225.

28. In the course of our visit to Poole we were particularly struck by the quantity of *Ulva* at a spot where anchorage for the weed was provided by mussels, brick-bats, etc., and by its absence from other parts of the harbour which did not offer it similar encouragement.

A still more striking instance of the importance of mussel beds as supplying anchorage was afforded by the luxuriant growths of *Ulva* in Southampton Water, where the plants examined were found in almost every case to be secured by mussel threads.

29. In addition to providing a mooring, it has also been suggested that the mussel helps to feed the *Ulva* by contributing ammonia from its excretions. Experiments made by Professor Letts indicate that a single living mussel in the course of twenty-four hours adds to half a litre of sea water an amount of ammonia equivalent to ½ per cent. Belfast sewage. Mr. Cutler and Mr. Hawthorne have also referred to excrement from mussels as food for *Ulva*. Cutler, 31136. Hawthorne, 31138.

Professor Letts has further suggested that *Ulva* may in turn be of service to the mussel by oxygenating the foul water in which mussels often grow. In support of this suggestion he made some further experiments from which it appeared that mussels would travel some distance towards fronds of *Ulva* to which they then attached themselves by their threads.

VI.—CHEMICAL EFFECTS OF SEWAGE POLLUTION UPON THE GROWTH OF *ULVA*.

30. We now come to discuss the effects of sewage pollution, and, conversely, of sewage purification, upon the growth of *Ulva*. As regards the particular case of Belfast, the position is somewhat affected by the provisions contained in the Local Act of 1899, to which we have referred.

31. The valuable investigations carried out by Professor Letts before we commenced our inquiry shewed :—

(1) That *Ulva* can rapidly absorb nitrogen presented to it in the form of saline ammonia contained in liquid sewage diluted with sea water.
(2) That in this way the growth of *Ulva* is encouraged.

Moreover there did not seem to be any reason to doubt that *Ulva* could, as represented by Professor Letts, also absorb nitrogen presented to it in the form of nitrate—the form in which it would mainly be found in a well purified effluent such as would be produced by ordinary methods of sewage purification. There was not, however, sufficient evidence to satisfy us that *Ulva* would be encouraged to an extent likely to cause nuisance if the nitrogen in the sewage were discharged mainly in the form of nitrate. Evidence on this point would clearly have an important bearing on the need for a scheme for the "denitrification" of sewage such as that elaborated by Professor Letts. But before investigating the degree to which *Ulva* can avail itself of nourishment furnished by nitrate it was necessary to ascertain beyond doubt whether the weed could grow freely in the absence of sewage whether treated or not. If this question could be answered in the affirmative any proposal either for the purification of sewage by ordinary methods or for its denitrification as a remedy for the *Ulva* nuisance would plainly have to be reconsidered.

32. The evidence at our disposal, then, required to be supplemented in several particulars. Accordingly, Professor Letts, with the assistance of Mr. Richards, instituted a large number of experiments with the object of comparing the growth of *Ulva* in pure sea water and in sea water mixed with various proportions of (*a*) tap water; (*b*) sewage; (*c*) purified sewage effluent; (*d*) sewage and tap water. A complete account of these experiments is given in the report by Professor Letts and Mr. Richards, which is printed in the Appendix hereto. The results of the different series of experiments were occasionally conflicting; for example, in one series the greatest growth occurred in the mixture of pure sea water and pure fresh water, and in some cases there was a greater growth in pure sea water than in polluted sea water. On the whole, however, the experiments point to the conclusion that, while *Ulva* can grow freely without any sewage pollution, the addition of nitrogen in a form which may be supplied by sewage is apt to produce rapid increase of the weed.

Appendix III.

VARIATIONS IN NITROGEN CONTENT OF *Ulva* GROWN IN PURE AND IN POLLUTED WATERS.

33. Several determinations have been made of nitrogen in *Ulva* growing both under natural and under artificial conditions. The proportions of nitrogen present in *Ulva* under different conditions is of importance as indicating (*a*) how much nitrogen the weed is capable of absorbing when the supply of nitrogenous matter is plentiful; and (*b*) how little nitrogen it requires for free growth when the supply is limited.

34. The following figures relating to *Ulva* growing under natural conditions are instructive :—

Locality.	Percentage nitrogen in dry *Ulva*.
(1) Clare Island (County Mayo) - - - - - - -	1·73
(2) Durlston (Dorset) - - - - - - - -	1·13
(3) Studland Bay (Dorset) - - - - - - - -	1·18

Analyses of samples of sea water from Durlston and Studland Bay showed that they were very pure chemically, containing only about one-tenth the quantity of ammoniacal nitrogen usually present in the upper waters of Belfast Lough. The water at Clare Island is understood to be unpolluted also.

35. On the other hand, *Ulva* taken from localities known to be polluted gave the following results:—

	Percentage nitrogen in dry *Ulva*.
(1) Belfast Lough (mean of twelve samples) - - - -	3·92
(2) Exmouth (Devon) - - - - - - - -	3·73
(3) Starcross (Devon) - - - - - - - -	3·65

The proportions of nitrogen are thus nearly as 1 : 3 in the two series. If we take individual samples from those on which the average for Belfast was calculated the variation is still greater, one frond containing 4·99 per cent.

36. It appears then that while *Ulva* will readily avail itself of the sustenance provided by polluting matters, it can also thrive on the exiguous diet derived from sea water which is not polluted by sewage. This is notably the case at Studland Bay, where we found *Ulva*, with a nitrogen content of only 1·18, growing in abundance.

37. Estimations have also been made of the nitrogen content in *Ulva* under artificial conditions, with the object of comparing the loss or gain of nitrogen in samples grown in pure sea water and mixtures of sea water with sewage and sprinkler effluent.

In all cases except one the samples grown in polluted waters showed a gain in nitrogen content. On the other hand, in two series out of five the samples grown in pure sea water showed a gain of nitrogen, but one of these was somewhat doubtful. We may conclude then that while, as a rule, *Ulva* grown in polluted water gains in nitrogen content, it is not impossible for it to show an increase of nitrogen when grown in pure sea water. It may further be observed that in no case did the samples of *Ulva* (which all came originally from polluted waters) show, when placed in pure sea water, a diminution of nitrogen content to the level of that found in *Ulva* taken from the above mentioned unpolluted localities.

38. With regard to the different degrees to which *Ulva* is nourished by pure and by polluted sea waters we think it desirable to point out that it has not been feasible in the time at our disposal to make an exhaustive examination of this subject. The experiments, however, together with our other investigations, have been sufficient to enable us to report on the matter.

NITROGEN CONTENT OF PURE SEA WATER.

39. The constituents of pure sea water are of importance in connection with the question of the development of *Ulva* in the absence of polluting matter, and determinations of nitrogen were made in several samples of pure sea water. It was found that nitrogen was present as free ammonia, albuminoid ammonia and nitrates in the following quantities, expressed as parts per 100,000:—

Free ammonia - - - - - - -	from	0·000	to	0·0014
Albuminoid ammonia - - - - - - -	,,	0·005	,,	0·011
Nitrates - - - - - - - -	,,	0·002	,,	0·009

These figures throw some light on the power of *Ulva* to thrive in pure sea water, especially as it is known that sea weeds can absorb relatively large quantities of certain elements, which are present in very small amount. The absorption of iodine by kelp may be cited as an example of this power.

It may be remarked that it has been shown by experiment that *Ulva* cannot absorb nitrogen in the form of albuminoid ammonia.

SULPHUR CONTENT OF *Ulva*.

40. Since the distinctive nuisance for which *Ulva* is responsible is due to the liberation of sulphuretted hydrogen when the weed decays, we considered that the sulphur content of the weed might afford some indication of the nuisance which, when rotting, it would be likely to cause. Estimations of sulphur have, therefore, been made in order to ascertain whether the sulphur content of *Ulva* growing in polluted and unpolluted waters bears any constant ratio to the nitrogen content. Unfortunately, owing to lack of time, it has not been possible to obtain a complete series, but the results, so far as they go, suggest that in samples taken from polluted waters the percentages of nitrogen and sulphur are very similar, but that in samples taken from pure sea water the sulphur content is considerably

greater than the nitrogen content. Thus, samples from Studland and Durlston with little more than 1 per cent. of nitrogen contain over 5 per cent. of sulphur, the exact percentages being 5·83 and 5·36 of sulphur in the two samples, whereas samples from Belfast Lough showing an average percentage of 4·11 nitrogen contain an average of no more than 4·43 per cent. sulphur. Given similar conditions of decay it would seem so far as the sulphuretted hydrogen is due to the sulphur in the weed, that bulk for bulk *Ulva* from unpolluted sources may be capable of causing at least as serious nuisance as *Ulva* from Belfast Lough.

VII.—REMEDIES.

Effect of Mussel Clearing.

41. Our investigations shew clearly that mussel beds are a very material factor in the excessive development of *Ulva ;* and the suggestion has been made that the clearing away of local mussel beds might result in a great diminution of the growth of *Ulva*. A small experiment was instituted at Belfast by our officers on these lines with satisfactory results. The improvement effected on the surface of the bank by the removal of mussels from a small area of slobland and the washing away of mud which incidentally followed, lasted for at least eight months, notwithstanding the fact that the area was surrounded by densely packed mussel banks. It must, however, be remarked that the observations related to the winter months.

Cutler, 31306–31329.

We thought it desirable that this experiment should be repeated on a much larger scale and in the summer months. On being informed of this view the City Corporation undertook the work. The results of this experiment are given in the report of Mr. Cutler, who states that an area much larger than before from which the mussels had been removed in May, 1910, was clear of organic mud, and remained practically clear of growing weed in September, this interval covering the season of most active growth.

Appendix VI.

42. We have not at present sufficient data to enable us to estimate the permanence of the effect of mussel clearing in abolishing seaweed nuisance. The time which might elapse before a fresh mussel bed appeared on a cleared area would doubtless vary under different local conditions. But on the evidence at our disposal we may properly recommend the process as a valuable temporary measure for the abatement of the evil in the special circumstances of Belfast.

Treatment by Sulphate of Copper.

43. We may here refer to another series of experiments which were designed to destroy both mussels and *Ulva* by treatment with sulphate of copper. This treatment was tried by Mr. Frye, on a small scale, in September, 1909, and on a larger scale in May, 1910. The effects in each instance were so marked a month later that the Corporation decided to treat in this way a considerably larger area. The results of the Corporation's 1910 experiments are given in Mr. Cutler's report. Appendix VI.

44. On consideration of these experiments we are led to the following conclusions :—

(1) That copper sulphate crystals when carefully distributed in the proportion of 1½ cwt. per acre over areas of slob covered with *Ulva* and similar weeds will destroy the weeds almost completely in the course of about a week.

(2) That this effect is only temporary, lasting about two months.

(3) That the application of copper sulphate by destroying weeds and to some extent killing the mussels assists the actual cleansing of the banks by the tides to a very marked extent.

(4) That some nuisance from smell through decomposition of the mussels thus killed may arise shortly after the application of the chemical, but beyond this, so far as the observations go, no serious disadvantage is likely to be caused.

45. We would, however, guard ourselves against being understood to recommend the clearing away or destruction of mussels as a remedy to be applied indiscriminately in all cases where mussels are associated with an undue growth of *Ulva*, without reference to varying local conditions. Mussels, apart from their commercial value, constitute the food of many kinds of marketable fish, and in many cases their destruction would not be warranted. We may also observe that, as copper sulphate is poisonous to fish, its use in some cases might not be justified.

Reclamation of Sloblands at Belfast.

46. While we are of opinion that in the special circumstances of Belfast the measures we have indicated, as well as the removal of accumulations of weed such as has been carried out by successive Joint Boards, are useful as temporary expedients for abating the nuisance, we consider that Belfast Lough cannot be permanently freed from the nuisance by such means. Indeed, our observations lead us to think that, as was originally suggested by Professor Letts, the only effective way of permanently removing the foreshore nuisance and preventing its recurrence would be provided by the reclamation of the sloblands on the County Down side of the Lough. The results of our own investigations agree with the evidence of most of the witnesses that the main nursery of the *Ulva* is to be found in that area, where the topographical conditions are singularly favourable to the growth of the weed.

Cutler, 31257–31305.

47. Mr. Cutler dealt at some length with the question of reclaiming this area. The work would no doubt be costly, especially if it were to be completed in two years, as he suggested was desirable. But the land reclaimed would come to have considerable value at a comparatively early date for agricultural purposes and later, probably, for purposes of the Corporation and the Harbour Board. Other witnesses agreed generally that the reclamation of the area in question was practicable and would be of great benefit to Belfast and its immediate neighbourhood; but some points in objection were raised.

Kelly, 31564. Murdoch, 31792.

Bell, 31849–31877.

48. One witness, Mr. Bell, discounted the effectiveness of this remedy by the suggestion that the greater growth of the weed is below low-water mark and would therefore be unaffected by reclamation. Our own observations, however, in no way support this contention.

Kelly, 31562–31582.

49. The representatives of the Harbour Commissioners raised the point that the reclamation would be injurious to the channel by reducing the scour of the tide, and thus increasing the work of dredging. But they did not regard the difficulty as a very serious one. Provided that the channel could be kept open they considered that the reclamation would be of great benefit to the harbour.

50. Other witnesses suggested that a reclamation scheme would have the effect of transferring the foreshore nuisance further down the Lough towards Cultra, and possibly across to the Antrim shore. We do not attach much weight to this suggestion. The efforts of the Joint Foreshore Board to collect and remove the decaying weed have, even under present conditions, been valuable in reducing the nuisance, though we think that their methods might be made more effective ; but if the proposed reclamation were carried out, the growth of *Ulva* would be so much reduced that any remaining accumulations of weed could be easily and quickly disposed of. Pending the completion of the reclamation scheme the removal of the mussel beds on the area or the use of copper sulphate would be of great service in reducing the facilities for anchorage and consequent growth of the *Ulva*.

51. In this connection it should be borne in mind that a superabundance of *Ulva* by its own seasonal decay produces in large amount, and in vicinity to the weed, the substances which go to furnish the chemical pabulum for fresh growth. These methods for checking the weed in its origin should therefore have a cumulative effect.

VIII.—OTHER SUGGESTIONS FOR IMPROVING THE CONDITION OF BELFAST LOUGH.

52. In February, 1910, after hearing the evidence of the parties interested, we considered that our inquiry was sufficiently advanced to permit us to make some preliminary suggestions for improving the condition of the Lough. Accordingly we wrote to the Corporation in the following terms :—

Royal Commission on Sewage Disposal,
5, Old Palace Yard, S.W.
February 19th, 1910.

Sir,

I am directed by the Royal Commission on Sewage Disposal to state for the information of the Corporation of Belfast that they have had under consideration the question whether they could, at this stage, make any recommendations in regard to the arrangements for disposing of the sewage of Belfast.

As the Corporation are aware the Commission have been making a number of scientific investigations in regard to the conditions obtaining in Belfast Lough. These investigations are not yet complete.

The Commission have, however, arrived at the following conclusions :—

(1) That the whole of the sewage of the City should be brought to one outfall at the northern side of the river and that no discharge should take place south of the River Lagan.

(2) That not less than three times the dry weather flow should be passed through sedimentation tanks under the conditions laid down by the Local Government Board for Ireland in their letter of April 27th, 1909.

(3) That the existing wooden chute is inefficient and that a properly constructed culvert or culverts should be provided capable of delivering the effluent from the sedimentation tanks during the first three and a half hours of the ebb at a point near to the outlet of the existing chute.

(4) That as far as practicable storm-overflows should be limited in the sense recommended in Para. 294 of the Fifth Report of the Commission.

In the opinion of the Commission the Corporation should carry out the above recommendations at the earliest practicable date.

I am at the same time to add that it appears to the Commission to be highly desirable that the Corporation should confer with the Belfast Harbour Commissioners with a view to the carrying out of a scheme of reclamation on the County Down shore.

Copies of this letter will be sent to the other parties interested.

I am, Sir,
Your obedient Servant,
(*Signed*) F. J. WILLIS,
Secretary.

The Town Clerk,
Belfast.

As regards sedimentation tanks we may explain that the conditions laid down by the Local Government Board for Ireland were as follows :—

1. The sedimentation tanks should be of such size that the sewage will take from twelve to fourteen hours to flow through them, assuming that they are used as " continuous flow " tanks. In other words the tanks in use *at one time* should have a working capacity of about one-half the *average* dry weather flow. The daily dry weather flow should be ascertained by gauging and not by merely multiplying the population by an assumed number of gallons per head per day.

2. The total tank capacity must be greater than half the dry weather flow to allow for cleaning, which requires to be carried out about once a week.

3. As it is possible that it may hereafter be desirable to provide for chemical precipitation of the sewage, so as to still further reduce the solids in suspension, the inlet to the tanks should be constructed so as to permit of this being conveniently done if necessary.

4. Considerable further quantities of suspended matter will settle in the reservoirs in which the sewage is to be held up so as only to discharge on the ebb tide, and this should not be discharged into the Lough but be pumped out and dealt with as sludge. The bottoms of these holding-up reservoirs should, therefore, be so constructed as to facilitate the removal of this sludge.

5. The inlet to these reservoirs should also be so arranged as to allow of the addition of lime or other precipitants to aid final settlement, and to prevent possible decomposition in hot weather.

6. The tanks should be so arranged as to permit of the filtration of the tank liquor should this further means of purification be hereafter found necessary.

53. We understand that the Corporation are now constructing works to comply with the above recommendations, and that, further, these works will, it is anticipated, be capable of dealing with sewage arriving in volume considerably in excess of three times the dry weather flow.

54. For the reasons which are given in an earlier portion of this report we think it of importance, apart from the question of *Ulva*, that storm water sewage should, as far as practicable, be treated at the works and not discharged in the neighbourhood of the works without previous settlement. If, with this object in view, it should be found necessary to supplement the provision for sedimentation, we may refer to the recommendation contained in Para. 295 of our Fifth Report.

IX.—PURIFICATION OF BELFAST SEWAGE.

55. In view of the foregoing considerations, we are of opinion that no higher degree of purification than that obtained by efficient sedimentation is necessary in the case of Belfast sewage. At the same time it may be wise to provide, as the Local Government Board for Ireland have recommended, for the possibility of some further treatment in the shape of chemical precipitation to aid in the sedimentation of the sewage. We consider that while sewage pollution, as also a certain proportion of fresh water, undoubtedly encourages the development of *Ulva*, other conditions to which we have referred—such as sheltered water and suitable anchorage—are essential for its growth in extra abundance. Where the physical conditions are as favourable to the growth of *Ulva* as they are at Belfast, complete purification of sewage, though it might tend to mitigate the nuisance, would not in our opinion remove it.

56. The novel scheme of denitrification proposed by Professor Letts has many features of value and interest. It was considered at that time of great importance to

eliminate as far as practicable from Belfast sewage the substances which especially nourished the growth of the weed. In such circumstances, the scheme elaborated by Professor Letts for the removal of nitrogen from the sewage would merit most careful consideration. But we are now satisfied that the nuisance cannot be effectively removed by any scheme limited to the treatment of Belfast sewage. Assuming that Belfast sewage has in the past greatly encouraged the growth of *Ulva* and assuming also that this source of nourishment were suddenly cut off, we think that the disappearance of *Ulva* would by no means necessarily follow. Other sources of chemical nourishment of the weed would remain available in the Lough,—temporarily if due to deposit on the banks from past sewage discharges, more permanently if resulting from the decay year by year of *Ulva* fronds, the supply of which would be seasonally renewed; moreover, it must be remembered that even if a complete scheme of filtration were adopted, a large amount of unfiltered sewage would, in times of heavy storms, necessarily find its way into the Lough.

We do not, however, consider, for the reasons which have been indicated, that pollution is essential to the growth of *Ulva*. The removal of sewage pollution could not therefore be a complete and certain remedy for the evil.

X.—UTILISATION OF *ULVA*.

Appendix III.

57. It may be desirable in cases where it may not be possible or convenient to prevent the growth of *Ulva* to turn its accumulations to some practical account, and we have instituted some experiments with the object of ascertaining how this may be effected. A complete account of these experiments will be found in the Report by Professor Letts and Mr. Richards. The object of the experiments was to ascertain whether *Ulva* could be profitably employed, either (1) directly as manure after drying and powdering, or (2) indirectly for the recovery of ammonium sulphate and other substances. As regards the first method, it was found that the moisture, amounting originally to 80–90 per cent., could be reduced to 24 per cent. by spreading and drying the weed in the air, thus greatly facilitating its removal. As regards the second, it is probable that recovery of ammonia, etc., might be made commercially profitable, but the success of the industry would depend on the sustained production of large quantities of *Ulva* with a corresponding risk of nuisance.

XI.—SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS IN REGARD TO BELFAST.

58. (1) Apart from the *Ulva* question, we think it essential, in order to prevent the silting up of the navigable channels and the deoxygenation of the water, that Belfast sewage should be freed from the bulk of its suspended solids before it is discharged into the Lough. The work necessary to effect this should be completed without delay.

(2) No part of Belfast sewage should be discharged to the south of the Lagan at Sydenham (as was proposed); the whole should be concentrated at the main outfall to the north.

(3) The present defective chute should be replaced by a watertight conduit or conduits or by steel piping.

(4) Storage should be provided at the outfall works to enable the discharge, within each 24 hours, of at least three times the mean dry weather flow; such discharge to be limited to the first 3½ hours of ebb tide.

(5) Storm sewage should, as far as practicable, not be discharged without previous settlement. If with this object in view it should be found necessary to supplement the provision for sedimentation we may refer to Para. 295 of our Fifth Report.

(6) Given effective sedimentation we do not recommend further purification of Belfast sewage. We do not doubt that a scheme of purification would tend to reduce the growth of *Ulva*, but having regard to the existing physical conditions which favour the growth of the weed, to the other sources of pollution which would not be removed by purification, and to the capacity of the weed to grow, when circumstances favour it, in sea water not polluted by sewage, it is impossible to predict that the reduction of growth would be sufficient to secure the removal of the nuisance.

(7) Since the main nursery of the *Ulva* lies on the south of the Old Channel from the mouth of the Connswater to Holywood, where the topographical conditions are singularly favourable to the growth of this weed, we hold that the reclamation of that area would provide the only certain and complete method of removing the nuisance and preventing its recurrence.

(8) Pending the completion of this work the removal of mussel beds on that area would greatly reduce the facilities for anchorage and consequent development of *Ulva*.

(9) Treatment of the *Ulva* banks with copper sulphate may serve as a supplementary means of checking and destroying excessive growth of the weed.

(10) The present system of collecting the weed drifted on to the south shore of the Lough has been valuable in reducing the nuisance, but we think it could be made still more effective.

(11) Spreading the weed and allowing it to be dried by the air would greatly facilitate its removal for application to land, where its nitrogenous qualities should be of value.

(12) The production from *Ulva* of ammonium sulphate and other substances might prove a commercial success. But any such process would probably be incompatible with effective measures for the suppression of *Ulva*.

XII.—GENERAL CONCLUSION.

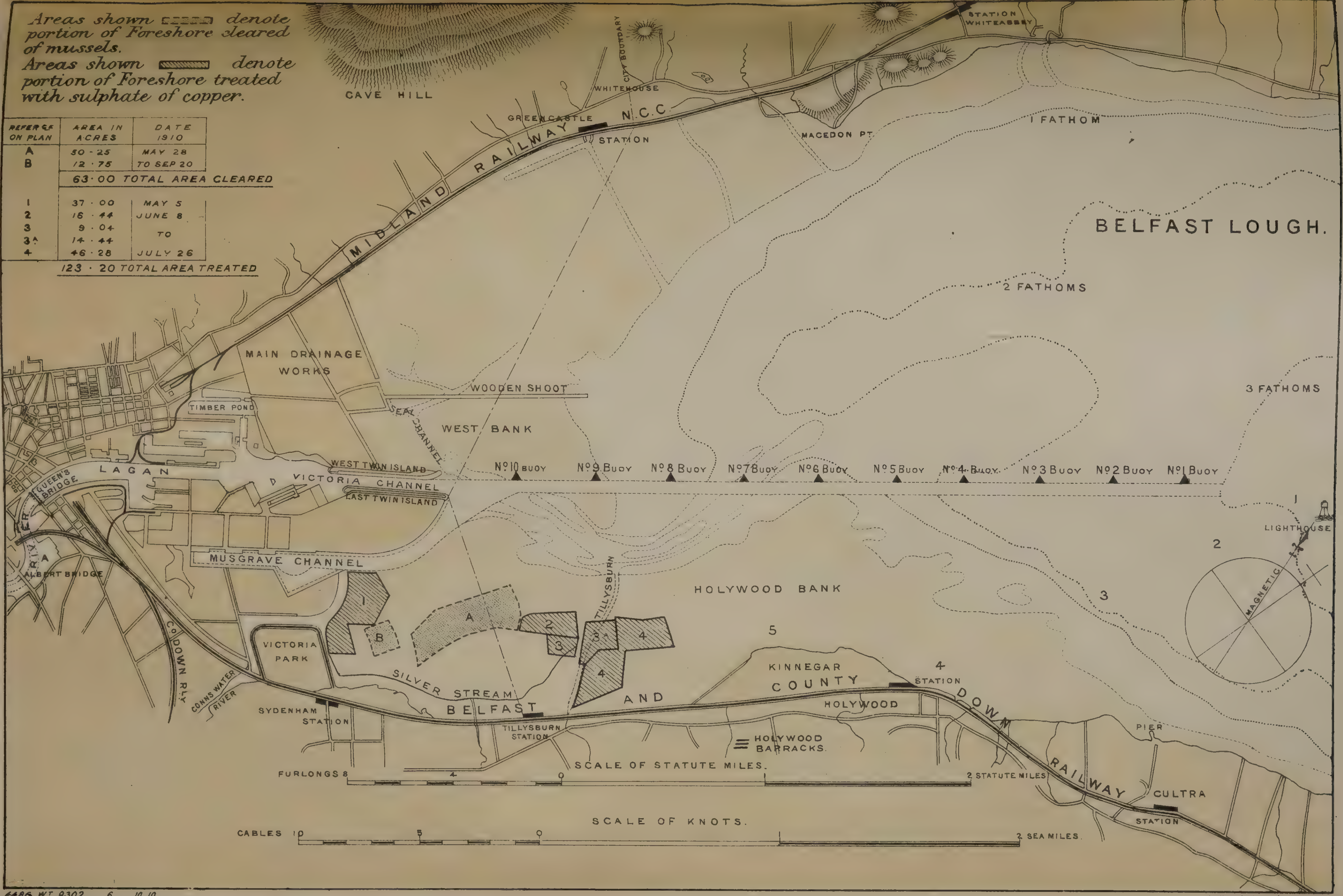
59. The foregoing conclusions relate primarily to the local conditions at Belfast. They are not to be taken as necessarily applicable to any place in which nuisance from *Ulva* is experienced. It is probable that in other cases some of the measures which we have indicated might have a remedial value. But it has not been possible in the time at our disposal to study the conditions of other localities as carefully as in the case of Belfast. Our experience of other places has been valuable for purposes of comparison, but it has not been sufficient to warrant us in arriving at any general conclusion other than that each case must be considered on its own merits, and that the problems and their solutions will differ in different circumstances.

The following Appendices will be issued in a separate volume:—

I. Evidence of witnesses.
II. Report by Mr. Frye and Mr. Kershaw upon an examination of Belfast Lough.
III. Report by Professor Letts and Mr. Richards.
IV. Botanical Report by Mr. Cotton.
V. Report by Mr. Frye and Mr. Kershaw on certain means for destroying or removing *Ulva*.
VI. Report by Mr. Cutler, City Surveyor of Belfast, on certain experiments carried out by him.

IDDESLEIGH (Chairman),
T. WALTER HARDING,
WILLIAM RAMSAY,
W. H. POWER,
T. J. STAFFORD,
R. A. TATTON,
F. J. WILLIS,

R. H. H. KEENLYSIDE (Secretary),
16th February, 1911.



Areas shown ▨ denote portion of Foreshore cleared of mussels.
Areas shown ▨ denote portion of Foreshore treated with sulphate of copper.

REFERENCE ON PLAN	AREA IN ACRES	DATE 1910
A	50 · 25	MAY 28
B	12 · 75	TO SEP 20
	63 · 00 TOTAL AREA CLEARED	
1	37 · 00	MAY 5
2	16 · 44	JUNE 8
3	9 · 04	TO
3A	14 · 44	
4	46 · 28	JULY 26
	123 · 20 TOTAL AREA TREATED	

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ROYAL COMMISSION ON SEWAGE DISPOSAL.

SEVENTH REPORT

OF

THE COMMISSIONERS

APPOINTED TO INQUIRE AND REPORT WHAT METHODS OF

Treating and Disposing of Sewage

(Including any Liquid from any Factory or Manufacturing Process)

MAY PROPERLY BE ADOPTED.

Nuisances due to excessive growths of Green Sea-weeds in Sewage Polluted Estuaries, with special reference to Belfast Lough.

VOL. II.—APPENDICES.—Part I. **Minutes of Evidence and Reports to the Commission in reference to Growths of Green Sea-weeds in Sewage Polluted Estuaries.**

Presented to both Houses of Parliament by Command of His Majesty.

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APPENDIX I.

MINUTES OF EVIDENCE AS TO NUISANCES DUE TO EXCESSIVE GROWTHS OF GREEN SEA-WEEDS IN SEWAGE POLLUTED ESTUARIES, WITH SPECIAL REFERENCE TO BELFAST LOUGH.

NINETY-SEVENTH DAY.

Tuesday, 15*th February*, 1910.

PRESENT :

Sir William Ramsay, K.C.B., F.R.S. (*in the Chair*).
Colonel T. W. Harding, J.P., D.L.
Sir William H. Power, K.C.B., F.R.S.
Mr. T. J. Stafford, C.B., F.R.C.S.I.
Mr. R. A. Tatton, M.Inst.C.E.
Mr. F. J. Willis (*Secretary*).

ALSO PRESENT :

Dr. A. C. Houston.
Dr. George McGowan.
Mr. C. C. Frye.
Mr. G. B. Kershaw.
Mr. E. H. Richards.

Mr. Henry Harrison, of Holywood, County Down ; and Mr. R. I. Calwell, C.E. (Consulting Engineer to Mr. Harrison), called in ; and Examined.

30628. (*Chairman.*) We are very much obliged to you, gentlemen, for coming and giving us the benefit of your knowledge of the district, and ideas as regards remedies. I think it would be convenient to question Mr. Harrison first ; Mr. Calwell will know more about the facts ; you could substantiate the facts later?—(*Mr. Harrison.*) Yes.

30629. That was the impression that we got from reading the evidence : that Mr. Calwell had furnished a great deal of the evidence on the Belfast sewage ?—We have been associated all through in the matter.

30630. That would be a convenient division for yourselves ?—Yes.

30631. Looking to this Paper which you have been kind enough to send in—an abstract of your evidence—would it be convenient to miss (*a*) and (*b*) at the present time ? (*a*) is evidence as to the action of tides and currents in the Estuary of the Lagan and upper Lough, and (*b*) is the examination of available evidence establishing facts as to the points of discharge and the volumes discharged from the Belfast Main Drainage Works ; and pass on at once to (*c*), leaving (*a*) and (*b*) for Mr. Calwell afterwards ?—Very well, Sir.

30632. That is our suggestion ; that would suit you ?—Yes, Sir.

30633. I will begin by asking you to put on record the first paragraph. You are the owner of an estate situated on the County Down shore of Belfast Lough, extending from the Belfast municipal boundary to the north-east boundary of Holywood urban district ?—Yes, Sir.

30634. That, you think, gives you a claim to be heard in the matter ?—Yes.

30635. And you think that the foreshore nuisance has greatly depreciated the value of your property ?—Undoubtedly.

30636. You have received frequent complaints from your tenants and neighbours as to the unbearable character of the nuisance ?—Yes.

30637. You have been familiar with the neighbourhood all your life, and have had general experience of it for thirty-five years ?—Yes, Sir.

30638. You have prepared and submitted to the Royal Commission this Memorandum on the subject, entitled "The Pollution by Sewage of the Belfast Lough as Associated with the Prolific Growth of the *Ulva Latissima*" ?—Yes.

30639. And that you bring forward, to begin with, in strong proof of the existence of widespread sewage pollution on the County Down foreshore, that there is a nuisance no one will deny ; the question is what is the reason of that nuisance ; is the nuisance wholly due to the decay of the *ulva* or do you contend that it is also produced by the deposition of sewage upon the shore ?—I contend that it is due in large measure to direct sewage pollution. The general evidence, without my pretending to any expert qualification whatsoever, depends upon the direct impressions created on one's senses and there is also the evidence which one has had of sewage pollution of the shell fish on the shores, and from the bacteriological examination made of specimens of mud principally and mud and water throughout the whole of what I have described in that Memorandum as the Tillysburn area.

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30640. We have a map here ; we see Tillysburn Station ; Tillysburn area is close to Tillysburn Station, I presume ?—From the quality and the odour of the mud which one finds in increasing quantities as one approaches low-water mark, and which is identical in its characteristics, so far as one's senses go as to smell and consistency with the mud which one finds in the region of the chute where it is admittedly the result of deposits of sewage matter, from the quality, the appearance and characteristics of the water which one finds in the region of low-water mark, and flowing up the slob channels.

30641. Is the colour of the mud black ?—You get a brown surface frequently with black underneath, but the prevailing colour is black.

30642. Does it smell ?—Very badly, very badly indeed ; and on a disturbance of this mud down to considerable depths you get large volumes of gas liberated, coming up through the water with really an appallingly bad odour.

30643. Are there remains of the *ulva* in the mud ?—No traceable remains.

30644. No visible fronds ?—No visible fronds, but I imagine that the process of decomposition would disintegrate the *ulva* fairly rapidly on the surface of those deeper deposits ; you cannot expect I imagine to find any vegetable matter which could be identified.

30645. It is a soft substance, the mud ; you sink into it ?—Yes, it is almost like pitch ; very clinging.

30646. Have you seen what happens when it is exposed to air ? Does it alter its colour ? I suppose that would require to be tried by taking away a specimen of mud and exposing it to air ?—I have not made the experiment at all, but perhaps I might add one further evidence. In the region of the low water mouth of the Tillysburn River one finds huge beds of *ulva latissima*.

30647. Growing ?—Growing and rooted on the surface of some of these beds. When one has passed over them in a boat in shallow water, one has seen what appeared to be sand deposited on the fronds. Well, on attempting to touch it or collect it one found it was flocculent matter, and it escaped one's hand at once, and the water all round became turbid. On other parts of the foreshore near the same place, where there is mud, *ulva* and mussels, you find frequently when you are walking through it that there is a certain amount of water retained by the weed and the rough surface, and that it immediately becomes turbid with a black or brown substance which would appear to be somewhat similar in character to the brown substance I first mentioned, perhaps having undergone some further change.

30648. (*Sir William Power*). Has the deposit on the surface of the fronds that you speak of been examined

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microscopically ?—I found great difficulty in collecting any specimen of it, and when I was present there with Professor M'Weeney, he acting as my bacteriological expert, we obtained some specimens of any floating weed which I thought at the time was a specimen of that adherent to the fronds. That I think Professor M'Weeney ascertained to be Beggiatoa, a fungoid growth which I imagine is not the same as the other.

30649. This deposit you are speaking of must be very abundant ?—Oh, yes, it must. It was not a small isolated phenomenon at all.

30650. (*Chairman*). Then you would require to rely on evidence on the direction of the currents in carrying sewage on to the County Down foreshore, in order to say definitely that this mud consists at all events partly of sewage. Have you any proof that it is sewage, and not merely decayed fronds of *ulva latissima* ?—We find what according to ordinary standards is apparently a great deal of pollution in the Tillysburn area, enormous in volume and intense in quality. When we find an enormous discharge of sewage within a reasonable distance we naturally trace a correspondence between the two. We then proceed to test the distribution of the water of the Lough, and we find by positive evidence a direct connecting link between the two.

30651. But there are currents on to this shore ?—There are direct currents representing at any rate a tendency which might take place once a week, twice a week, or six days a week. I do not know how that may be, but I think it does occur and it does prove a definite tendency, and from that we are entitled to infer that there is a correspondence between the sewage discharge in the one place and the prevalence of polluted matter, or apparently polluted matter, in the Tillysburn area.

30652. Do you lay any importance on the analysis of the water in that part of the Lough ?—We have not attached great importance to it ; we have not gone very far in regard to the analysis of water because we considered that we found the connecting link between the two ; we have the pollution in the mud, and we have evidence of sewage pollution wherever we found *ulva*.

30653. I think it is necessary to draw a distinction between two things, the actual presence of excrementitious matter on these slob lands and the presence of the *ulva*. You have no doubt that its luxuriance is due to its growing in sewage polluted water ?—Yes.

30654. But I should like you to draw the distinction. You think there is actual excrementitious matter washed on to this shore ?—I have found actual excrementitious matter, due undoubtedly in my view to tidal action on that shore ; but I do not attribute the nuisance to the coarser solids, which appear to me only to arrive there very occasionally and in small quantities, but I do attribute the pollution to the finer suspended solids, and also to dissolved impurities.

30655. Actual sewage brought on to the shore as well as the *ulva latissima ?*—Actual sewage brought on to the shore, oh yes ; and, of course, I made the point in my Memorandum that if the *ulva latissima* is a product of sewage pollution, or is fertilised by sewage pollution, where the *ulva latissima* can come the sewage polluted water which nourished it at the bed of growth can also come.

30656. Do you attach much weight to the smell ? You spoke of the smell ; I have seen the place myself and I know something about that smell ?—I am not aware whether you experienced it at its worst.

30657. It is now five years ago, and I remember noticing at the time the very strong smell, and talking to the driver of my car about the state of his harness which turned black very quickly, and was black at the time. That, of course, was due to sulphuretted hydrogen ; but do you think the smell of the mud is that of sewage ?—Well, of course, I have only my own unaided senses and untutored experience to go on, but the smell is exactly that of stale sewage. Of course, in the Memorandum I distinguish between various odours that we get on different occasions. There is the smell which you get from an accumulation of *ulva* in process of active decomposition, a scummy patch which gives a catch in the throat, as well as a sulphuretted hydrogen smell. There is a smell which you get sometimes, particularly with the wind blowing directly from the pumping station, of fresh sewage. There is a normally fœtid smell, not a very strong one, on that beach ; but there is a smell which arises occasionally, not very often, but more particularly on a still night than on a still day, with over-hanging clouds, which is appalling in its effects. I mean, sleeping half a mile away from the shore, 100 feet above the level of the Lough, with an open window at night, one has been awakened on frequent occasions by this smell with a sensation almost of pain in the nostrils ; and that is not an isolated experience of my own ; it has been repeated to me by many people living there, who find it necessary to keep their windows shut.

30658. (*Sir William Power*). That is not a rotten egg smell, you say ?—It is not an ordinary sulphuretted hydrogen smell ; it is more intense, more stale.

30659. (*Chairman*). Is it something like that, would you mind telling me (*Handing phial to Witness*) ?—Oh, that is mild compared to it.

30660. Mild compared to it. Is it of the same nature ; the same character as that ?—Much more concentrated.

30661. But that character of smell ?—There is a staler flavour, if I may so describe it.

30662. Perhaps you may wish to know what that is. That is from the top of the filters of London water. The London water passes through sand filters, and that is the weed which is collected from the top of the filters. I asked you to smell it, to show you that you can get a smell of that sort from substances which are not in any way polluted with sewage, but which are merely vegetable matters ?—I have seen that stated.

30663. Decomposing vegetable matter gives that sort of smell. I wanted to know whether that is the smell which you complain of ?—The other is, as I say, much more concentrated, but it would be perfectly easy if the Commission wished it to get specimens of the gas which comes up out of the mud.

30664. I should think it was very largely sewage gas, but it would be interesting to find out ?—It is very offensive.

30665. Marsh gas and carbonic acid are not offensive ; it is what they carry with them, and of course the whole process of anærobic decomposition which leads to the formation of marsh gas and carbonic dioxide. Would it not be convenient to pause here, having considered (*c*) in your Memorandum, and ask the other members of the Commission if they wish to enlarge on this subject ?—Yes.

30666. (*Sir William Power.*) I should like, with reference to matters in your Memorandum, to get some of the chronological relations of certain of them on the Minutes. First about the period 1880–1890 as to foreshore nuisance ; was it definitely increasing throughout that decennium ?—My general experience was that it was occasional at first, and not very strong ; it became rather more frequent and stronger.

30667. As the time went on ?—As the time went on.

30668. And did that growing nuisance extend over the whole of the area you have under consideration, as far down as Holywood or Kinnegar ?—It is in what I described in the plan on that Memorandum as the Tillysburn area.

30669. That is the area opposite Sydenham ?—The land lying between the Victoria Park Embankment and Kinnegar. It was principally in the region of Tillysburn.

30670. And the condition of the foreshore in that area as regards mussels, mud and *ulva*, was it somewhat similar to what we see there now, or less in degree, or was it comparatively innocent of pollution ?—The evidences of pollution were infinitely less than they are now.

30671. But the same in character generally ?—I think there was less *ulva*.

30672. And do you think the deposit of mud was equally thick on the banks ?—I do not think there was so much mud as now. Residents of very long experience in the neighbourhood assure me—a gentleman who lives in a house close on to the area—that the level of the banks has, in his experience, been raised considerably in that area.

30673. The whole of the Tillysburn area ?—Yes.

30674. In what space of time would that be, in fifty years or so ?—Forty or fifty years.

30675. (*Chairman.*) Do you mean the level of the slob banks ?—Yes.

30676. (*Sir William Power.*) Do you think these slobs are still rising ?—I would not venture to express an opinion about it myself; I only quoted this gentleman, who is, I think, about ninety-five years of age, and he lives there.

30677. They were rising then before the physical conditions were altered to the extent they are now; in 1890, were the banks rising then ?—That apparently is his experience.

30678. Then I should like to get a few words from you as to whether during that time there was any corresponding increase of pollution contributed from the County Down shore itself. Now, first as to the Connswater in those days, was that bringing a good deal of undesirable fluid refuse, town sewage and otherwise ?—My impression is that the Connswater was more polluted in those days than at present, but I would rather you addressed that question to Mr. Calwell, who has long experience as a practising engineer in Belfast.

30679. And then the Silver Stream; would that be much the same thing as now as regards the amount of liquid refuse it brought down ?—The Silver Stream, Sir, is almost entirely a stream draining the slob lands of such waters as are on the slob land.

30680. I know, but there is some exit of water from the land about Sydenham Station ?—Yes, at Sydenham Station there is a drain which discharges a certain amount of crude sewage, which has recently been increased.

30681. That was not increasing at that time; is that the same now as at that time ?—Yes; rather more now than it was then. It has increased in the last twelve months, but for many years past there had been some four or five hundred houses, I think, in the region of Sydenham, of which the majority probably are drained on to the beach at Sydenham Station.

30682. And now as to the Tillysburn itself, as to the condition of the Tillysburn stream in those days, was that bringing much down in the nature of sewage ?—There is no change I should think in regard to it; the number of houses in the neighbourhood remains the same, the large houses. There was a small village population inland, which has more or less disappeared, but then, as now, there is no actual sewage in the Tillysburn River at all. There is a small overflow from two different septic tanks, which overflow reaches these rivers about a quarter of a mile, roughly speaking, from the shore.

30683. A quarter of a mile inland from the high-water mark ?—Yes, from the outfall. The Tillysburn River, perhaps I might explain, Sir, consists of three streams. The principal one runs all the way from Holywood along the railway line. Into that stream a certain amount of sewage is discharged in Holywood, but the bacteriological examination which I had made of that stream recently by Professor M'Weeney showed no sign of sewage pollution near the outfall at all. It is a very slow flowing stream, exposed to the influences of light and air, and there is considerable vegetation in it, and apparently it undergoes a natural process of purification before it arrives at the Tillysburn outfall. Another stream at that outfall is a little stream which comes down directly under the road; that is excellent pure water, except that there is an overflow from a septic tank belonging to Colonel McCance's establishment, a house with stables and so on, and that overflow passes into it. That water, I happen to know when passing under the road, is drunk by the people round about. Then there is a little stream which comes from the other side, which contains an overflow from a septic tank from a house called "Richmond Lodge."

30684. (*Chairman.*) It receives sewage only in the case of storm overflow. Is the liquid filtered after it passes the septic tank ?—It is one of these rather primitive septic tanks that accumulate sewage matter in it, and they clear it out periodically.

30685. It does not pass over filters afterwards ?—No, I think not.

30686. (*Sir William Power.*) There is one little stream at Kinnegar Point. We saw an outfall from a military establishment, when we were down there, but that did not exist I suppose in 1890, did it ?—No, that did not exist; the outfall which you saw only came into existence about 1906, very late in 1906, I think. Prior to that, for a period from about 1898 to 1906, there was a discharge from a long pipe drain running out just where the word Kinnegar is on the map; from Kinnegar Point it was running out I suppose 40 yards directly at right angles to the shore.

30687. On to the foreshore ?—On to the foreshore.

30688. Discharging on to the foreshore ?—That was crude sewage for such time as it existed, from about 1898 to 1906. Then about 1906 the military authorities put in a system for the bacteriological treatment of their sewage. It has been working ever since and the effluent from it discharges at the back of the rifle targets at Kinnegar; that would be the discharge which you saw. Beside that, there is a small culvert which is entirely innocent of sewage matter. It is merely a drain to carry land water from the back of the reclamation embankment.

30689. (*Mr. Stafford.*) There were no barracks at all there before 1898; is not that so ?—There were no barracks.

30690. (*Sir William Power.*) Then your view is that at that time, 1880–1890, the total contribution of a deleterious kind from the County Down shore was insignificant ? —Then as now, Sir.

30691. And you think it is so now; that is what I was coming to ?—Yes.

30692. There is no great difference between 1890 and the present day as to the pollution of the shore itself from the land on the County Down side ?—There is no alteration at all, except the introduction of this treated effluent from the military barracks.

30693. That is to say what came crude on to the foreshore is now treated before it comes there ?—Prior to 1898, there was no military sewage in the district at all.

30694. By 1890 the foreshore nuisance had become so great that a Joint Board was established of riparian authorities, was it not ?—Yes, Sir.

30695. What did that consist of; the urban district of Holywood ?—The urban and rural districts were not constituted at that time; it was the Town Commissioners of Holywood and the Belfast Guardians, I think.

30696. And those were the only two bodies that were concerned in it ?—Those were the two Public Health Authorities.

30697. Castlereagh did not exist then as a rural authority ?—No, Sir.

30698. What were their functions; were their functions to cleanse at the high-water mark or to cleanse the shores generally ?—Well, I have not verified the references but I think it was to cleanse generally; to take such steps as might be necessary to remove the nuisance.

30699. And can you say in general terms what it was they did, what amount they removed from year to year, and whether they worked over the whole of the area, the Tillysburn area ?—I would prefer, if the Commission wishes it, to produce other evidence of the persons who actually participated in the work; I am not really familiar with it.

30700. The next point I want is, at what precise date did they cease to operate. They came to an end; did they come automatically to an end; did the conditions of their constitution end them; or did they cease because there was no longer need for carrying on the work ?—Well, I should like to get you direct evidence on that, but the evidence which I am aware has been given is to the effect that they ceased their work before the expiration of the period for which they were appointed, because it was anticipated that the coming into operation of the Belfast Main Drainage works would obviate the necessity for their doing any further work.

30701. Not that the nuisance was rapidly diminishing ? —I think not, Sir; I think it was rather in anticipation that the cause would be removed.

30702. They ceased to operate; and about what date can you say the chute began to come into service, do you know ?—The evidence that was given was that the chute came into operation in 1893, but that there was some

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temporary outlet of a similar nature to the chute in operation, I think, from 1891.

30703. And where would that be in operation, at the Western Islands, by the Seal Channel or where ?—On a line, I think, parallel to the existing chute and pretty close to it, Sir.

30704. But it would be very much nearer Belfast, would it not ?—I think it was on the seaward side of the present main-drainage embankment that that temporary outlet was worked.

30705. I suppose they began to connect up the sewers by intercepting sewers, for preventing the pollution of the Lagan within the City very much antecedent to 1893, did they not ?—Yes, Sir, because so soon as they were using a temporary outlet some of the intercepting sewers must of course have been working.

30706. You do not know absolutely where the temporary outlet became operative, do you ?—No, I could not actually fix it, Sir. I am rather referring now to evidence which has been given.

30707. It was not where the present storm overflow is, at the site of the new works near the commencement of the chute, was it ; you think it was further citywards, do you ?—Oh, yes, it was quite distinct from any existing outfall.

30708. Then subsequent to 1893, what date can you give us when there was distinct evidence that the nuisance was once more increasing again in the Tillysburn area, because in 1898 I think you formally waited by deputation, did you not, upon the Corporation of Belfast, representing the nuisance was as bad or worse than ever before ? How soon did it begin to be in evidence, that whatever had been done, was not operating in a satisfactory way ?—The character of the nuisance changed. The geographical position of the nuisance was also shifted. The nuisance instead of being in our view, in the nature a sewage nuisance principally in the Tillysburn area, became a weed nuisance, mainly a weed nuisance which evidenced itself in its most concentrated and objectionable form further down the shore at Cultra, and on the lower side of Holywood, and there was an abatement of the nuisance in the Tillysburn area.

30709. Do you think the extra nuisance coincided with a great increase in the abundance of the weed in the Tillysburn area ?—There was a great increase in the abundance of the weed. No one talked about the *ulva latissima* till the end of the last century.

30710. Then in 1880–90, the period about which I first began to ask you, the *ulva latissima* was not so much in evidence as in 1890 was it ?—I never heard its name mentioned. It was a sewage nuisance ; it was regarded always as a sewage nuisance ; in those days the weed was not conspicuous in amount ; of course, it was observable.

30711. (*Chairman.*) There were no very large deposits as there are now ?—No, Sir, there were not. But there were enormous deposits towards the end of the 1890–1900 period, especially down at Cultra.

30712. (*Mr. Tatton.*) Was the nuisance from the *ulva* similar to the nuisance from the sewage, or was it separate ; I mean the smell and so on ?—My impression is that one did not have, to anything like the same extent, these large scummy patches of decomposing *ulva*, where the *ulva* is to be seen in process of decomposition. We did not have that to anything like the same extent.

30713. You speak of the early nuisance as a sewage nuisance pure and simple ?—That was the way we always regarded it and there was less *ulva* in evidence.

30714. Yes, there was no *ulva* growth there, or at any rate very little *ulva* growth ?—Very much less than we have at present.

30715. (*Sir William Power.*) But you have not at all connected the *ulva* with the nuisance in those days, had you ?—I never heard the name of the *ulva* as such mentioned ; a certain amount of seaweed was referred to.

30716. (*Mr. Tatton.*) But practically it was the same thing ; you had a continuous nuisance going on all the time ?—Much less after the Main Drainage works were installed, much less at the Tillysburn area.

30717. A distinct improvement ?—A distinct improvement, yes.

30718. But you had more weed after that ?—The weed was found very much further down the shore, but it then began to increase in the Tillysburn area fairly gradually.

30719. Is there more nuisance now than there was, say ten years ago ?—Once again the place, in which the nuisance shows itself most, has changed. Cultra has been considerably relieved, and Tillysburn has become very much worse. We attribute that to the alteration in the point of discharge of the sewage which has been effected in the last decade, and to the operation of the Seal Channel and the Old Channel, driving it over towards us, driving it into the shallow waters where the deposits are more easily made, where the weed is more easily fertilised. It does not get away from the point of the chute where it would tend to affect Cultra more.

30720. Is there a nuisance in the winter and spring, or is it only in the summer and autumn ?—The nuisance persists up till the end of the year. I have had complaints of an extremely bad smell as late as Christmas Day, and after Christmas Day in the Tillysburn area ; but after that there is not very much of it, I mean you may get a faint fœtid odour, that sort of thing, but there is not very much in our view at all till the heat of the summer begins to be felt.

30721. (*Chairman.*) That means June, I suppose ?—It begins before that.

30722. (*Mr. Tatton.*) Then is the nuisance that you get in the winter from the decaying *ulva*, or has the decaying *ulva* been washed away by that time ?—There is no sign as a rule of any *ulva* in process of decomposition in the winter.

30723. Have you beds, or is it growing in the winter there still ?—No, we do not see the weed ; we see little or none of it ; the beds are bare of it ; the slob lands are bare.

30724. And, therefore, how do you account for the nuisance you found on Christmas Day, when the *ulva* was not present at all ?—One's explanation of that is, that there are exhalations from the mud.

30725. Before these muddy deposits took place, were they sand banks originally ; can you go back as far as that ?—There was a good deal of sand. I think people used to walk from Holywood to Belfast, fairly far out near high-water and from my own recollection on the slope of the Kinnegar in the first half of the 'seventies all my people from Holywood House used to bathe from the Kinnegar in the sea ; the children were sent down and the nurses and so on to bathe. Now, nobody would dream of bathing on that shore ; bathing has been stopped there ; it has been stopped at Holywood down to Cultra.

30726. That would be thirty years ago ?—In the early 'seventies, as a child I used to bathe there off the Kinnegar slope.

30727. Of course, the sewage pollution at that time was very bad further up, I suppose, higher up ?—The sewage pollution at that time was in the River Lagan. The nuisance which we got in the Tillysburn Area at that time I attribute entirely to sewage matter which did come down the Lagan, such of it as was not deposited in the Lagan and did not undergo a natural process of purification in the Lagan, was brought down and followed that bend in the river's course to the low-water mouth, if I may so describe it, of the Tillysburn River. If there was sewage in the water there at low-water that sewage necessarily would pass up the channel of the Tillysburn River and cover the adjoining slob land.

30728. (*Sir William Power.*) On the flood ?—Yes, the moment the tide begins to rise. I have proved that very clearly with one of our experiments with confetti. We took a boat at the dead ebb, about 150 yards from the low-water mouth of the Tillysburn River. We rowed up and down a straight line of about 250 to 300 yards, and we sowed that line very thickly with confetti. We then waited, and we saw this line carried towards the low-water mouth. We saw it converging from the Belfast end and the other end and practically the whole of the confetti was carried up the low-water mouth of the Tillysburn River. We followed it up, and saw the little tributaries especially on the Kinnegar side. We followed it as long as the light would allow us. That was on the Friday evening. On the following afternoon Mr. Calwell

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and myself went out to look for the results, and all through the north-eastern end of the Tillysburn area we found the confetti in the mud; we found them in the little slob channels and in such places as you would find slack water, resulting from two slob currents meeting; we found it deposited there. We found, however, that the bulk of the confetti had apparently floated, and that we had not accounted for nearly all our confetti. We went on and, as we came around to the Kinnegar Point, we found at high-water mark, on the two sides of the Point, huge rolls of *ulva*, and enormous quantities of confetti for about 40 or 50 yards on the Point Kinnegar towards Belfast, and I suppose a couple of hundred yards down the other side of the Point. And, oddly enough, we found at the same time abundant traces of a sewage current. We found enough human excrement to have filled a large wheelbarrow and we found bits of sticks and the wood-spools of cotton that had been used, and corks and things of that sort with this human excrement. The human excrement had lost its shape largely; it had been rolled by the tide's action into large potato-like masses, but there was no mistaking what it was.

30729. On that occasion that you put the confetti off the mouth of the Tillysburn, did you on the rising tide find it carried up the Silver Stream as well, or did you not follow that out?—We did not have an opportunity of going round to the Silver Stream.

30730. Your point is that what collects in Pool of Garmoyle on the last of the ebb is, by the rise of the tide, spread throughout the Tillysburn area?—Yes, Sir.

30731. And do you think it would spread up the Silver Stream area as well, though you had not observed that?—We would have had to sow our confetti rather more widely; we put it fairly near to the mouth of the Tillysburn river.

30732. You thought it practically exhausted in going up the Tillysburn?—Practically the whole of it. Both ends of the line converged. I think there is no doubt whatever that a similar test from an appropriate spot would show that the flood tide does run up the Musgrave Channel into the Connswater and into the Silver Stream. I do not think there can be any doubt about that.

30733. (*Chairman.*) Do you think that the excrementitious matter comes down the chute, up the exit, or does it come down the Seal Channel?—Well, Sir, the evidence which I endeavour to give in the Memorandum, from independent sources, goes to show that the bulk, the major proportion of the Belfast sewage for the last decade, has been so discharged as to come within the operation of the Seal Channel basin, and to be carried down the Seal Channel. There has been some controversy occasionally as to the operation of the Seal Channel, but there is a current of from three to four knots.

30734. Outwards?—Outwards; that is at right angles practically to the Victoria Channel. There is a notice up there warning bathers, such people as are ill-advised enough to bathe in the fluid which is to be found there, that their lives are endangered by the current. And once you trace the Seal Channel into the Victoria Channel you then find, from experiments made by the City Surveyor and Dr. Letts, that one of their floats at least pursued the line of the old Channel, and was so described by the City Surveyor himself as having pursued the line of the old Channel.

30735. (*Mr. Stafford.*) Let us get back again to (*c*), the existence of widespread sewage pollution. Both in your printed statement, Mr. Harrison, and in your replies to the Chairman, you relied very strongly, or rather insisted very strongly, on the point that this is sewage pollution?—Yes.

30736. And you base this opinion chiefly upon the evidence of your senses?—And of my bacteriological expert.

30737. Well, we heard the first part about your senses; now about your bacteriological expert. You have given us a very short extract from Professor M'Weeney's Report?—I have various Reports from him.

30738. Might the Commission have those Reports?—I prefer to produce Professor M'Weeney. Reports which are framed for the purpose of an action in the Law Courts one does not always wish to make public.

30739. The reason I ask is this, there is very little detail, he gives a very strong opinion, no doubt, but he does not back that opinion up by anything in the nature of evidence. For instance, he does not tell us the number of *bacillus coli* or *enteritidis sporogenes* or of *streptococci*; he does not give us any figures; he merely gives us a statement?—Oh, I think he does.

30740. P. 104, Appendix (F)?—Not p. 104, but Appendix (B) on p. 91, or rather that part of that you find on p. 93.

30741. He took four samples, he states on p. 93, on August 18th, from different parts of the slob and found them to contain the characteristic sewage organisms in considerable numbers. Two of the muds yielded so much *coli*, the third so much. I say there is not very much detail on p. 93?—Of course, it was for the purpose of proof in a law action, and I do not think Professor M'Weeney anticipated a scientific discussion or no doubt he would have put greater elaboration of detail.

30742. Yes, but it would be a very good thing if the Commission had some more elaborate detail, since you rely upon your bacteriological examination?—Yes.

30743. You think he was there sufficiently often to have made a sufficiently close examination to be a reliable witness?—I only asked him to come down till he was satisfied, had satisfied his own mind as to the cause, and was prepared to submit himself to cross-examination in the Law Courts on the point. Might I direct attention to one point in his Report as to whether the nuisance is attributable to seaweed only, or to sewage only, or to seaweed and sewage combined. You will find that one of his examinations was an examination of fluid matter draining from that large and offensive heap in the Tillysburn field. The heap consists of material which has been collected off the foreshore by the Joint Foreshore Board, and which is spoken of as being *ulva* collections, and he found that full of *bacillus coli* and *sporogenes enteritidis*, which I understand are accepted as characteristic micro-organisms of sewage pollution.

30744. I will not press the point, as you suggest calling Professor M'Weeney at a later date. Now, about the confetti which you distributed; what is the prevailing wind in Belfast?—I have not actually verified it, but from my general experience, westerly and south-westerly.

30745. What was the state of the wind when you put down the confetti?—It was almost a flat calm; such breeze, if any, was south-west, south-west by south, but it was absolutely flat calm; the surface of the water was unruffled.

30746. You would agree that the wind would have a very great effect upon the line which your confetti took?—The wind would have a very considerable effect on the surface of the water, and possibly on the distribution of the current more than a mere surface current.

30747. So it was important to know what the condition of the wind was when you made these experiments?—At the beginning of the experiment, as I have stated, it was flat calm.

30748. But that would not be the prevailing condition in Belfast?—No.

30749. The westerly wind would be?—The westerly wind would be, but the westerly wind would tend of course to accentuate the tendency of sewage to find its way across the Tillysburn area.

30750. From where?—Westerly or north-westerly.

30751. From where; from what point?—Down the line of the Seal Channel, and the old Channel.

30752. I am starting at the chute; if the prevailing wind is west, starting at the chute, how could confetti get back to the Tillysburn and Connswater area?—From the chute?

30753. Yes.

30754. (*Chairman.*) From the end of the chute?—Well, Sir, I was dealing with what has been occurring in the last ten years. There was no sewage discharge from the end of the chute during the last ten years.

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30755. (*Mr. Stafford.*) From any portion? If it was at the end of the chute, or the middle of the chute it would be just the same thing?—The answer to that is, if it was discharged from the chute within a distance of 3,200 feet from the pumping-station embankment at any period from about the first two to two-and-a-half hours of the ebb, wind or no wind, it would have to come down the Seal Channel, because there is no other way for it to get away.

30756. Did you put any of your confetti down by the chute?—No. The confetti in the second experiment, which has not been explained yet, was put in the Seal Channel some 200 or 300 yards up from the Victoria Channel, in the middle of the current which flows down the Seal Channel to the Victoria Channel.

30757. If you had wanted to know the distribution of the sewage, ought you not to have put your confetti at the chute?—I do not think so necessarily.

30758. The sewage comes at some portion of the chute?—Not always; a very large proportion of it has been discharged through the pumping-station embankment.

30759. That is merely a question at which end of the chute; one end or other of the chute?—No; at the corner of the pumping-station embankment nearest to the Twin Island there is a culvert of 4 by 4—they call it the 4 by 4 culvert—which we have seen discharging enormous masses of sewage, discharging so strongly that it washes a 7-lb. iron weight 100 feet or more.

30760. Surely you admit that most of the sewage from Belfast comes from some portion of the chute?—During the latter portion of the last decade, the majority has not gone through chute during legal hours.

30761. Through any portion of the chute?—Through any portion of the chute.

30762. Or through a discharge near the chute?—Yes, a discharge near the chute, at the pumping-station embankment.

30763. (*Chairman.*) Is that the black mark on that map?—That is the actual building in the middle of the reclamation; that is the pumping-station itself.

30764. (*Mr. Stafford.*) But that is only about 100 yards from the end of the chute?—Well, it is 100 yards nearer.

30765. That is practically the chute?—Oh, yes.

30766. If you were making a test of this sort, why not put down your confetti at the place where the sewage was coming out?—May I explain. If you defer your cross, examination on this point till we get further with the float experiments, you will find we have put floats at the points where the sewage was seen coming from the chute, and that we did in fact trace them down to Seal Channel and across the Victoria Channel.

30767. (*Chairman.*) Would it not be convenient to follow that up now; to hear what became of the confetti put into the Seal Channel and to give evidence as to the action of tides and currents in the estuary of the Lagan and Upper Lough. It would be convenient to take these points now, I think. I do not know whether Mr. Calwell wants to give evidence specially on this matter, or whether Mr. Harrison would answer this question?—(*Mr. Calwell.*) Mr. Harrison was with me.

30768. Perhaps, Mr. Harrison, you will make a complete statement now as to what those experiments were?—(*Mr. Harrison.*) Yes.

30769. (*Mr. Stafford.*) You have some plans or charts to illustrate your experiments?—Yes. Mr. Calwell is getting some plans showing the course of certain of our floats. The second confetti experiment was designed to supplement the one which I have already described, the one which showed the action of the flood tide in carrying the fluid which is lying in the bend of the old Channel up into the Tillysburn area. In point of logical sequence the test which comes next is the test of confetti and oil placed in the Seal Channel some couple of hundred yards up from its point of confluence with the Victoria Channel, because at first there was controversy as to whether there was any current in the Seal Channel at all, and when that was established, it was suggested that such current as came down the Seal Channel was merged in the current in the Victoria Channel, and carried directly sea-ward. As that seemed to be in conflict with what seemed to be the initial probabilities of the case, we made a test with oil and confetti to see what would occur in the case of sewage matter floating down the Seal Channel, and I may say, Sir, that sitting in a boat in the Seal Channel for the purpose of watching floats and so on, we have frequently found obvious excrementitious matter passing us. The boatmen have fished it up and put it in bottles for us to test and so on.

30770. Are you speaking now of the second experiment?—Of the second experiment.

30771. As regards the second experiment, can you tell me what was the condition of the wind in the second experiment?—The condition of the wind in that case was a wind blowing from the west, with I think a little of the north in it.

30772. A north-west wind you think?—Yes.

30773. That is not the prevailing wind in Belfast?—A very common wind.

30774. But not the prevailing wind?—Not the prevailing wind. But with great respect, Sir, all I found necessary to prove for my purpose was that there was a tendency to occasional currents, to tolerably frequent occasional currents, because that would point to a tolerably frequent pollution of the Tillysburn area by sewage from the pumping-station, which for my purpose was sufficient.

30775. You think for your purpose that it was sufficient to show that there was occasional pollution there?—A tolerably frequent occasional pollution of the Tillysburn area, direct pollution, yes.

30776. But this north-west wind then was the most suitable wind for proving your point?—Undoubtedly.

30777. Was it selected for that purpose, or was it selected by chance?—I think it was a coincidence.

30778. I gather from your map here that your north-west wind would bring your confetti, your oil or anything else, anything on the surface, directly down the Seal Channel, and directly on to Tillysburn, and that that is the only wind that would do so?—That might be a legitimate inference from the single experiment, but not from all the experiments, because you will find in other of our float experiments, that our floats crossed the Victoria Channel into the old Channel and the Musgrave Channel when the wind conditions were not such as to influence them in that direction.

30779. Then we might discard that second experiment?—Certainly not, Sir, with great respect.

30780. But why?—Surely it has a most material bearing on the whole problem. If it is shown that with the wind in that quarter you get a direct flow down the Seal Channel, across to the Tillysburn area.

30781. Can you show us how frequently the wind is in that quarter?—I do not profess to have made systematic observations.

30782. There would be observations, of course, made in Belfast Lough which would show us?—I daresay there are, but I would not be competent to speak about that. I understand Queen's College keeps a record of the winds.

30783. (*Sir William Power*). What class of floats were you experimenting with then; were they floats which would be affected by the wind, or were they floats loaded so that the wind would affect them but little and the currents would affect them most?—When we were experimenting with floats we had some deep floats and we had some shallow floats, but the experiment Mr. Stafford is referring to at present was oil and confetti.

30784. And no floats?—No; the oil was specially selected as offering the least resisting surface to the wind.

30785. It was the surface currents you were testing?—The surface currents, because you find a good deal of the sewage matter is on the surface.

30786. (*Mr. Stafford.*) How many confetti experiments did you make?—This one I have already detailed, and the present one I am speaking of; they were so striking and so direct that we did not think it necessary to elaborate.

30787. (*Chairman.*) May I point out that on p. 46 you mention: "A fresh breeze was blowing from the south-west by west." In the second paragraph, on p. 46 you say: "On July 30th, 1908, Mr. Calwell, in the presence of the writer, again experimented with the current in the Seal Channel. The time of high-water was 11.57 a.m. and a fresh breeze was blowing from the south-west by west"?—The wind was not in that case absolutely behind us; it was slightly diagonal, but its main tendency would have assisted us.

30788. On July 28th, 1908: "A moderate breeze was blowing from the north-east by east;" the exact opposite?—Yes. That first experiment was a small one on which I did not insist. We found the oil crossed the Victoria Channel when the wind was unfavourable, and was not following the line pursued by the oil.

30789. (*Mr. Stafford.*) Was this in the first experiment?—No; it is a minor experiment which is detailed in this Memorandum, but which, as it was a minor experiment, I did not lay much stress on at the moment, but it does tend to dissipate your difficulty, Sir, as to the effect of the wind.

30790. (*Sir William Power.*) I do not think we have got in the evidence the state of the tide when you made these experiments. Would you give the exact stage of the ebb at which you did them; take July 28th first?—On July 28th, the time of high-water was 10.50 a.m., and a moderate breeze was blowing from the north-east by east, almost directly contrary to the line of the Seal Channel. The oil was poured at a latish stage of the ebb into the centre of the Seal Channel at 3.15 p.m., and we traced the track of the oil across the Victoria Channel into the line of the old Channel.

30791. (*Mr. Stafford.*) I still have not made out why you put your confetti, or your oil into the Seal Channel instead of at the chute?—Because the journey to be pursued by the sewage, being a long one, we preferred to take it by stages which would illustrate tidal action just as well as if we endeavoured to take it in one long journey which possibly might not be completed in a single tide or with the amount of daylight available.

30792. But is it not a fairer test to put it where the sewage exit is, where the sewage comes out?—But is it not an equally good test if you put it at a point to which you trace the sewage on another occasion?

30793. Well, I do not think it is?—I do not suggest for a minute that you could go out every day in the week and find a direct flow of sewage from the chute or the pumping-station embankment directly on to the County Down shore; I am only concerned to show tendencies.

30794. Why did you select the Seal Channel?—The reason for that is that there has been considerable controversy at previous inquiries in which it was denied positively that there was any current down the Seal Channel at all, and when it came to be admitted that there was a current down the Seal Channel, it was denied positively that it could cross the Victoria Channel into the line of the old Channel. What we were concerned to prove by these experiments, and what I submit with great respect we proved conclusively by these experiments, is that matter coming down the Seal Channel does, under certain conditions, if not on all occasions, cross the Victoria Channel into the line of the old Channel, down which it would naturally be taken towards the Tillysburn low-water mouth.

30795. Now, let us go on to the float experiments; what were the float experiments you made?—We made certain float experiments, Sir, from the outlet point of the chute where the sewage did not issue; we made float experiments from that point in the chute.

30796. You mean the point of discharge?—The legitimate outlet point; we also made experiments from points in the chute where we found the sewage actually issuing.

30797. What were the floats like, the construction of the floats?—They were floats which we borrowed from the Harbour Authorities, a shaft on the top, a certain amount of wood below and a weight underneath, some of them floating at a little depth and some at a lower depth, but in the case of all of them, I think there was nothing above the surface of the water except the mere shaft.

30798. Did you put these floats down upon several occasions?—Yes, Sir, on several occasions.

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30799. How many floats did you put down?—I think eight different experiments are shown.*

30800. Will you tell us the result of the eight experiments?—No. 1 was on September 18th, 1907, high-water was 7.25 a.m., mean tide 10.34 a.m., the wind was south-west, but faint. A float (*this is marked No.* 1) was placed in the water at the end of the chute at 10.14 a.m.; that you will see is twenty minutes before half-tide.

30801. How many floats did you put down there?—Just one float. What we were concerned to see was, what, if the chute were working, would be the path pursued by the sewage which would be coming out towards the end of the hours of legitimate discharge.

30802. (*Sir William Power.*) What was the wind at that time, did you say?—South-west, a faint wind. I recollect quite well the surface of the water was quite calm.

30803. (*Mr. Stafford.*) And that float went down to about No. 5 buoy?—That float sloped inward across the old Channel, near to the Victoria Channel, opposite No. 6 buoy; it then pursued a course parallel with the Victoria Channel.

30804. Did it cross the Victoria Channel?—It did not cross it, no; it then got into slack water apparently between two currents.

30805. In fact it ran down the wind?—It also answered certain tidal currents. The wind I should say, Sir, was not sufficient on that occasion to materially affect the course of the float at all, but the inference which I would draw from that particular experiment, which is not a very important one, is that the general tendency from the point of the chute is towards the line of the Old Channel on the County Antrim side of the Victoria Channel, but that it got into slack water between two main lines of current, the one on the Whitehouse Roads and the other parallel to the County Down shore, the current which is referred to in Chapter II. of the Memorandum.

30806. (*Sir William Power.*) What happened to that float on the flood; did you observe it on the incoming tide?—No, Sir, we were too late, but you will find in some of the other experiments that the effect of the incoming tide is shown. I refer to that experiment, principally as showing that there is slack water, or a tendency to slack water between these two currents, between the main line of the Old Channel and the subsidiary line of flood and ebb which comes along parallel to the line of the County Down shore.

30807. That is getting on to dead low-water is it not, when you had that?—It was near the end of the ebb tide, yes.

30808. (*Mr. Stafford.*) Did any of your floats cross the Channel?—Oh, yes.

30809. Show us the one that did; how many of them crossed the Channel?—If you will permit me, Sir, I would like to take them in order in which they are here. No. 2. on September 18th, 1907, high-water 7.25 a.m. and meantide 10.34, faint south-west wind. This float pursued almost an identical course to No. 1. It simply verifies the general tendency towards the centre of the Lough and the slack water between the two currents.

30810. (*Sir William Power.*) It was put in at the same stage?—About two minutes difference.

30811. And force of the wind about the same?—About the same; faint south-west. High-water was 7.25 a.m.; the float was put in about twenty minutes before half-tide. Then, Sir, No. 3 on September 18th.

30812. (*Mr. Stafford.*) Is this the same date?—The same date.

30813. And practically the same hour?—No. 2 practically the same hour, yes; No. 3 is on September 18th. This float was placed adjoining the chute where an actual discharge of sewage was perceived. It is about 3,200 feet from the Pump Station Embankment.

30814. (*Sir William Power.*) Would that be about midway in the chute?—A little more than mid-way.

30815. More than mid-way?—About 3,200 feet out of 5,200 odd feet.

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* The charts illustrating the float experiments will be found at the end of Mr. Harrison's and Mr. Calwell's evidence.

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30816. (*Mr. Stafford.*) At what state of the tide was this put down ?—This float was placed in the water at 10.30 a.m., half-tide being 10.34, and therefore it was placed in the water thirty-four minutes before the end of the period during which a discharge could legally be made.

30817. It was on the same date ?—On the same date. That float pursued a course inside the containing bank, called the West Bank, it came down the Seal Channel, it revolved for some little time in an eddy at the mouth of the Seal Channel, caused apparently by the two Channels meeting, and some interference with it possibly occurred owing to the passage of two steamers. You will find there was another float there at the same time, from a subsequent experiment. It left that eddy and it passed downwards slightly on the County Antrim side of the Victoria Channel. It got down to the point marked (*a*), where its position was accurately determined, and it subsequently came straight across the Victoria Channel to the Pool of Garmoyle.

30818. (*Colonel Harding.*) Was that with the returning tide ?—Yes, on the change of tide. We give the observation points (*a*) and (*b*) on the Chart, and, of course, the curve by which we connect these points is more or less imaginary, but the points were observed and the hours were observed and apparently the rising tide striking the rising ground of the outer slope of the West Bank carried it straight across and we found it practically in the Pool of Garmoyle.

30819. (*Mr. Stafford.*) That was not put down at the mouth of the chute ; that was put down as you say half way up ?—That was put down as illustrating the effect of the Seal Channel Basin and as illustrating a discharge we observed at the moment the float was placed in the water.

30820. (*Sir William Power.*) What was the state of the tide when that float arrived at point (*b*) ; was the flood making then ?—Mean tide was 10.34 ; it was at point (*b*) at 2.41 ; that would be substantially an hour after low-water.

30821. (*Mr. Tatton.*) You took it up then ; you did not follow it any further ?—We went down the Lough to look after the other floats which were lower down, and when we came back the float had disappeared, somebody had removed it. It is not an unusual experience in Belfast Lough ; if you do not stand by and watch your float, somebody removes it. The next is number 4. No. 4 was placed in the Seal Channel at a point some 100 yards or so from its confluence from the Victoria Channel and the circumstances under which we came to put it in were these.

30822. (*Mr. Stafford.*) Is that the same date, the same state of tide, the same state of wind ?—We were waiting the advent of the float mentioned in the last experiment which took some time.

30823. It has practically done what the other float did ?—Something of the same nature. We placed it in the Seal Channel, it got into the eddy, the same eddy that the other float subsequently came and joined it in. They both revolved in the eddy for some time, were perhaps detached from the eddy by the action of the passing steamer, and passed down slowly on the County Antrim side of the Victoria Channel. It was caught by the returning flood and carried up the line of the old Channel. It started up that line ; we were unable to pursue it much later because darkness was closing in.

30824. (*Sir William Power.*) Neither of them crossed the Victoria Channel. At the south side of the Pool of Garmoyle they both crossed over to the Down side of the Victoria Channel ?—Neither of them crossed the Victoria Channel at the point where the Seal Channel joins it ; they were caught in the eddy to which I refer and whether the two passing steamers interferred with them or not, I cannot say, but they certainly went down.

30825. They did not take the course of the confetti and the oil ?—No, Sir.

30826. (*Mr. Stafford.*) And they neither of them crossed till they were caught by the incoming tide ?—Neither of them crossed till they were caught by the incoming tide. No. 5 was a float which was placed in the water in the course of following one of the previous floats at the point (*b*), which represented roughly a line in which we found sewage matter coming from the chute down towards the main channel. This experiment is interesting principally as showing the tendency of the current referred to in the Second Chapter of the Memorandum.

30827. Is this the same date again ?—Yes, the same date ; a current across to the County Down shore ; it did not actually cross the Victoria Channel on the ebb ; it got close to it, it was caught then on the returning flood, it was carried directly up the line of the old Channel.

30828. And again that did not cross the Victoria Channel till it was met by the incoming tide ?—That was not brought within the influence of any current which could carry it with any tide across the Victoria Channel.

30829. (*Sir William Power.*) What was the state of the tide when it was put in ?—That was put in at 11.30 a.m.

30830. That would be the state of the ebb ?—Mean-tide was 10.34 ; 11.30 would be an hour after half-tide.

30831. An hour after half-tide ?—Yes.

30832. (*Mr. Stafford.*) It has pursued very much the same course as the other two ?—Yes, Sir.

30833. You made the start further out ?—One uses it to show the tendency of a particular current which would carry it down along the County Down shore if it was started rather earlier, but also to show the direction of the incoming flood tide across the line of the Victoria Channel out toward the County Down shore in illustration of my point that the Victoria Channel has not altered the tidal currents in the estuary, has not materially altered them, and that they remain as they were before the Victoria Channel was cut. No. 6 was on July 19th, with a south-east wind.

30834. The state of the tide ?—High-water 8.31 a.m., low-water 2.44, mean-tide 11.38. The float was placed in the water at a point of an observed actual discharge from the chute at 10.43 a.m.

30835. (*Sir William Power.*) About an hour before half-tide ?—Yes, roughly speaking, rather more than three-quarters of an hour before half-tide.

30836. And it was placed there you say ?—At a point about 3,200 feet from the main drainage embankment, about two-thirds of the way down the chute.

30837. (*Mr. Stafford.*) And you placed it at the Antrim side of the chute ; is that so ?—I could not tell you whether it was a yard or two on the one side or the other. I think we threw it into the middle of the discharge actually where it was bubbling up from the chute.

30838. It looks from the illustration there as if you put it on the Antrim side ?—That is because it passed out on that side, but it only shows the starting point. It only shows that the wind had a considerable influence on it, and that is our general observation that the surface tracks of the sewage, when it issued from the top of the chute, correspond very largely with the way the wind is blowing ; surface matter is blown over a good deal on the one side or the other.

30839. The wind in Belfast is a westerly wind, the tendency is therefore generally to take away the sewage from the Connswater ?—It would tend to take away the surface layers of the water, but it could not possibly prevail against any current which depends upon banks or channels. There again, this float found its way down to slack water between the two main lines of current, but the point at which it began to turn is shown. The next is No. 7. This was made on July 19th, and it was placed in the water in the Seal Channel some 100 yards or so above the point at which the Seal Channel joins the Victoria Channel.

30840. At what hour was this put in ?—High-water 8.31 a.m., low-water 2.44 p.m., a south-east wind.

30841. Was this the same date ?—July 19th, 1907.

30842. That is the same date as the previous one ?—The same date as No. 6, yes ; also a south-east wind.

30843. (*Colonel Harding.*) At what time was the float started ?—Mean-tide was 11.38 and this float was placed in the water in the Seal Channel at 12.23 which is about a quarter of an hour or twenty minutes after the expiry of the legal hour of discharge.

30844. (*Sir William Power.*) And about fifty minutes after half-tide ?—And about fifty minutes after half-tide.

30845. (*Mr. Stafford.*) It was promptly caught by the returning tide and brought back into the Musgrave

Channel ?—The point of the experiment, if I may explain it, is that the float was carried across the Victoria Channel into the line of the old Channel. It went some little distance down, round the buoy, it was then caught by the returning flood and carried up the Musgrave Channel.

30846. (*Sir William Power.*) That was against the wind ?—It went down against the wind; it was carried across the Victoria Channel in the teeth of the opposing wind.

30847. (*Mr. Stafford.*) At what time did it turn ?—It got into slackish water and then it returned by the Musgrave Channel. The inference of course which one draws from that, Sir, is, that matter coming down the Seal Channel can cross the Victoria Channel in spite of adverse wind influences. Once across the Victoria Channel it comes within the influence of the old Channel, and its natural flow, so long as the ebb continues, is down the line of the old Channel towards the Tillysburn River.

30848. That is the first of your floats which has got anywhere near the Tillysburn ?—It is a float which illustrates the tendency of matter in the Seal Channel, in spite of wind influences, to cross the Victoria Channel.

30849. It is also the first of your floats which has got back upon the Tillysburn Bank ?—The two previous floats came across to the Pool of Garmoyle.

30850. To the Pool of Garmoyle, yes, but none came back to the Connswater, or the Tillysburn Bank ?—Yes, Sir, but the two previous ones which crossed to the Pool of Garmoyle show you a discharge of sewage within the period of one ebb and flow could find its way on to the County Down slob banks.

30851. (*Chairman.*) Then you regard it, Mr. Harrison, as certain that a certain portion of the sewage, at all events, can find its way on to Tillysburn area under suitable conditions of tide and wind ?—Yes, Sir, we only endeavoured to prove that; we were not engaged in a scientific investigation.

30852. You think you have proved that, under certain conditions of tide and wind, a certain amount of sewage gets on to the Tillysburn area ? If it gets on to the Tillysburn River it drifts up ?—Yes, and more than that, we point to results which show that there are tidal current tendencies which tend to reproduce these results a very large number of times in the year and a very large number of times in the week.

30853. (*Mr. Stafford.*) Is this the last of your float experiments ?—No. 8, yes.

30854. Is this on the same date ?—Yes, on the same date, and it was practically made at the same time as the last one.

30855. That float went back to the Seal Channel I see ?—This is taken at the chute at a point not quite half way down from the Pumping Station Embankment, at a point where we found an actual discharge of sewage taking place It took a slightly curved route inside the Seal Channel Basin, it passed down the Seal Channel it crossed the Victoria Channel to the close neighbourhood of one of the buoys marking the old Channel and it then got into slack water and was carried by the flood tide back across the Victoria Channel into the Seal Channel again.

30856. Just one question and that is about all these experiments put together. It seems that no float put down at the end of the chute, that is the exit of the chute, found its way across the Victoria Channel; is that so ?—That is so, but in the experiment No. 5, a float was put down in the course pursued by the sewage which did not come out from the point of the chute.

30857. My point is, about the end of the chute; anything you put about the point of the chute in the shape of a float has not crossed the Victoria Channel ?—Our actual experiments show no result of it coming back, but from the point of view which we adopt we are willing to admit that a discharge made from a chute of full available sectional capacity during permitted hours, the bulk of it would not cause as much damage as is now done to the Tillysburn area.

30858. I gather that is your point ?—We might get a certain amount of the end of the discharge brought back on the flood tide.

30859. (*Mr. Tatton.*) I am not quite clear about this second culvert; can you show us where that second culvert is that discharges in or towards the Seal Channel in your Chart. It is one you speak of as having a considerable flow ?—If you take the angle of the Pumping Station Embankment nearest the West Twin Island, roughly speaking, it faces out parallel to the chute, but it is quite close to the corner.

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30860. It faces out parallel to the chute ?—Yes, it faces out parallel to the chute.

30861. It does not tend therefore to discharge direct into the Seal Channel ?—Oh, yes; there is a branch of the Seal Channel you will observe which runs across the face of the Pumping Station, a clearly defined channel.

30862. What size is that culvert ?—4 feet by 4 feet.

30863. Do they discharge direct into it from the sewer ?—The history of it, so far as I have been able to gather it from the evidence given on previous occasions is that it was created about 1901, that it was used for discharging from that additional low-level storage reservoir, as it is called, sewage which could not be discharged from the chute or which it was inconvenient to discharge from the chute. There was a good deal of evidence given in regard to it at a Local Government Board Inquiry in December, 1904, and then the City Surveyor stated that when he came to Belfast a year previously they had been discharging at all states of the tide because they had no sufficient storage accommodation to enable them to comply with the statutory requirements; and he stated that he had rendered available this storage reservoir with the necessary culvert which now enabled him to comply with the statutory obligations. At the same time there was a certain amount of controversial evidence as to the condition of the chute which he, no doubt on evidence supplied to him by subordinate officials, described as being in a fairly good condition and as enabling him to comply with the statutory requirements. It subsequently was proved, and was demonstrated by figures which I give in this Memorandum furnished from Corporation sources, that the chute was silted up for at least 75 per cent. of its depth, or nearly 75 per cent. of its depth, and that it could not have discharged the full dry weather flow of the Belfast sewage during legal hours, and the amount of sewage necessarily impounded owing to the slow discharging capacity of the chute, was stored in this additional low-level storage reservoir which has a capacity estimated by the City Surveyor of from 8,000,000 to 10,000,000 gallons. The level of it is very low and it would be impossible, owing to the levels, to discharge more than a small proportion of the sewage impounded in the reservoir during legal hours from the chute, or during legal hours at all. The result necessarily followed that large masses of sewage were accumulated in the reservoir which were let out, I think, mostly at night from this 4 by 4 culvert.

30864. (*Chairman.*) At low-water ?—At low-water or approaching low-water, because the bottom of the storage reservoir had the same level as the adjoining slob and a good deal of evidence could be produced of the facts. There was a controversy as to whether these things took place, and, of course, city officials are accustomed sometimes to see things as they think their employers would like to have them, but experiments were made by a competent witness who could be produced who, finding his evidence challenged that this 4 by 4 culvert used to discharge at night, put a 7-lb. iron weight with a little bit of wood attached to it in the culvert and retrieved it the following day at a distance of 70 to 100 feet away.

30865. In the slob ?—In the adjacent slob channel. Besides, anybody who saw the place would see that there was a channel cut through the mud bank into that adjoining Seal Channel, showing that this culvert was habitually used for a large volume of sewage. And if one may give one's own experience (I think Mr. Calwell has the date) we landed at the Pumping Station one day and found a great deal of sewage ponded up in this low-level storage reservoir. We remained there till the end of the legal hours for discharge and none of it was discharged, and we could see from the levels that practically none of it could be discharged, because of the level of the tide outside. We left then at about half-past six in the evening and we paid a surprise visit later. I regret to say that we had to scale a fence to pay this surprise visit. We arrived there at about 10.30 o'clock at night; we found this 4 by 4 culvert wide open streaming the sewage on to

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the slob at a condition of the tide closely approaching low-water; it may be a little before or it may be a little after; it would be a little after low-water, the tide would be beginning to rise then, but the reservoir was not then empty.

30866. Can they send sludge out of that culvert as well as sewage?—That was untreated sewage, absolutely untreated sewage; the bulk of it would not have passed even through the screen-house.

30867. (*Chairman.*) And you think this is a regular performance?—From the evidence of a watcher who has watched daily for years, it is a chronic performance and from the levels and volumes dealt with and from the choked condition of the chute it must have been the case.

30868. (*Mr. Tatton.*) Is the level of the outlet from the tank at the level of the bottom of the tank?—From this low-level reservoir on to the slob?

30869. Yes, through this 4 feet culvert?—The 4 by 4 culvert?

30870. Does it drain it off right to the bottom?—Practically to the bottom.

30871. (*Chairman.*) They practically empty this reservoir?—Yes, there is no other way in which it could be absolutely emptied; there is no lower-level culvert.

30872. (*Colonel Harding.*) I should like to ask Mr. Harrison one or two questions. You have expressed a strong opinion that the extensive black mud found upon the banks of the Tillysburn, on the shores of the Tillysburn to Holywood are due not only to decaying *ulva*, but to direct sewage contamination?—Yes, Sir.

30873. And I gather that your chief reason for forming that opinion is inference, that inasmuch as enormous quantities of sewage are discharged from the main outfall of the Belfast Corporation on the north side of the Channel it is possible for some parts of that discharge to be washed across the Channel and on to the Tillysburn banks?—Well, that is a necessary inference. A large proportion of it, having regard to the observed effects of tides and currents, is clearly carried across.

30874. Then you would agree, would you not, that if the discharge were limited to the ebb, these matters could not reach the Tillysburn bank until they were brought by a returning tide and had been submitted to large dilution?—If the discharge were strictly limited to the legal hours and the true point of the discharge.

30875. If that was so?—I am inclined to think we would get nothing but a return flow which would be largely diluted and all the coarser solids at least suspended.

30876. If it be a fact that the Corporation of Belfast has not limited its discharge to the permitted hours, and if it be a fact that the discharge has not taken place at the mouth of the chute, but has taken place at intermediate points of the works and not at the chute, and if it be a fact further that there have been independent discharges through the secondary culvert that you have mentioned, these discharges taking place on a rising tide, might finally be washed over to the Tillysburn area?—Not necessarily a rising tide; principally on the ebb tide.

30877. If there was a discharge on a rising tide out of the permitted hours the tide would naturally carry it to the shores?—The tide would naturally carry such discharges in the direction which the flood tide is pursuing, which will vary according to the different channels through which it is flowing.

30878. No doubt?—But the tendencies I have observed are rather ebb tide tendencies which carry sewage from the Seal Channel, passing over to the Tillysburn Area and the Pool of Garmoyle and they are then distributed by the rising tide over the Tillysburn Area.

30879. They are first taken by the ebb tide towards the sea and then turned round and brought back again?—The later discharge on the ebb tide would only reach Garmoyle and the Tillysburn Area.

30880. The currents are not rapid and therefore they would not have travelled far towards the sea before they are carried back, but you would agree the evils would be much greater if the discharges took place from the main outfall outside the permitted hours?—Do you mean a legitimate outfall or an illegitimate outfall.

30881. An illegitimate discharge?—The later they are on the ebb, the more they stand to injure us.

30882. That is evident is it not?—I think so.

30883. And if there is a discharge during the rising tide the danger would be still greater that the sewage would be carried over to the Tillysburn area?—It is, however, more likely to be diluted before it reaches us and more widely distributed.

30884. You have laid much stress upon your experiments with the confetti?—Yes, Sir.

30885. They were thrown into the water apparently at low tide, near the low-water mouth of the Tillysburn?—Yes, at absolutely dead ebb.

30886. Naturally you would expect them to be brought back again by the returning tide towards the shore up the path of the Tillysburn stream?—Yes, Sir; the experiment was designed to show that the north-east end of the Tillysburn area is filled with tidal water through the medium of the Tillysburn Channel, and not by the direct seaward route.

30887. Then the conclusion you came to was that matters floating down the Seal Channel from the main outfall would be carried up towards Tillysburn in this way?—Such of them as reached that pool in the old Channel would tend on the rising tide to flow up the Tillysburn Channel.

30888. And then you call attention to the masses of human excrement of unmistakable odour and consistency which had been rolled by wave action upon the southern beach. That is on page 45 of your Memorandum?—Yes, Sir.

30889. And do you seriously suggest to us that these masses of human excrement have been brought up on the same line as your confetti from the Seal Channel?—I cannot attribute any other origin to them, Sir. I do not suggest that this is a universal tendency or an invariable tendency; I say it is an occasional tendency.

30890. I do not know whether it is in your Memorandum or whether it was in the few words which Mr. Calwell addressed to us, but something was said, that there was sufficient to fill a barrow?—Yes, I said so.

30891. Then do you suggest to us that human fœces, after passing through the pumps of the Belfast Corporation and being wafted about on the Lough for some hours before they could reach that point, would still be solid fœces?—Yes, Sir. Pardon me, may I qualify that somewhat? I do not admit of course for a moment, that the whole had passed through the pumps. It does not pass through the pumps; that is our experience; we can prove it from various sources. My experience is that I have seen similar human excrement in the Seal Channel. I have also seen similar human excrement down the Lough, down here, when we were tending some of those floats away down Whitehouse Roads.

30892. But you would agree, would you not, that it is quite unlikely that human fœces of that kind could come through the pumped sewage?—Yes, but in these days the bulk of the sewage was not pumped, a large proportion of it was not pumped.

30893. In what days?—Within the last decade; they are pumping rather more lately.

30894. If the sewage was not pumped, by what channel would it reach the works?—It can flow by gravitation down to the Main Drainage works and can flow straight through without being pumped at all.

30895. (*Sir William Power.*) It cannot pass through the chute without being pumped?—Oh, yes.

30896. *Colonel Harding.*) But it must be pumped to reach the sedimentation tank, must it not?—The sedimentation tank has only been in operation since October, 1908.

30897. As a sedimentation tank, but it has been in operation as a storage tank?—As a storage tank, yes.

30898. And in order to fill that tank it is necessary that the sewage should be pumped?——Yes.

30899. You do not think it likely that solid fœces could survive the ordeal of pumping?—I do not imagine it would, Sir, but there were many discharges as we informed you.

30900. Whether these masses of human excrement which you saw on that occasion came from the main outfall or from some other source ?—I do not at all recognise the objection which you make, Sir, as being fatal. We are aware that large masses of human excrement come out through the chute and these other openings, because we have seen them ; we have seen them passing down the Seal Channel ; we have seen them passing out below the chute.

30901. Have you not a population of some 10,000 men at the great Shipbuilding Works of Messrs. Harland & Wolff whose fœces pass down the main Channel and pass the end of the mouth of the Seal Channel ?—The Shipyard population of Messrs. Harland & Wolff's Works do drain, that is their daylight sewage is drained into the River Lagan at the point between the Twin Island.

30902. It is untreated ?—It is untreated.

30903. And not in any way pumped ?—Oh, no, not in any way pumped.

30904. And therefore any fœces which you found anywhere near the mouth of the Seal Channel might conceivably more likely come from that source ?—It could not be found coming down the Seal Channel on the ebb tide.

30905. What I wanted to know was, do you seriously suggest to us—I am using your own words—that the masses of human excrement of unmistakeable odour and consistency which you found on that particular occasion, on the south shore of the Lough, had come from the main outfall on the Antrim side of the Channel ?—It was of such a character and the general flotsam and jetsam found with it is so abundant, that I could only assume that it came from the main sewage current, that it was not a mere small trifling phenomenon.

30906. (*Chairman.*) You say that the actual excrement has been in the Seal Channel at ebb tide ?—Yes, with the current running down.

30907. That, in your view, shows that it must have comes from the main drainage works ?—I said previously, when speaking of it, the boatmen were taking it out of the water and putting it into receptacles in the boat for us to test it.

30908. (*Colonel Harding.*) But there is the fact to be borne in mind that the sewage from 10,000 persons in the day-time is discharged by gravitation, without treatment and without any pumping, into the main channel, and passes the end of the Seal Channel ?—Yes, Sir.

30909. And at certain times of the tide would be washed up the Seal Channel to come down again afterwards ?—That is conceivably possible to that extent.

30910. It is more likely it might come from that source than the Main Outfall ?—I have seen it issuing from the chute, and I have seen it at the sump, the mixing tank, which is discharged into the chute, large masses of it.

30911. If it came from the chute it must necessarily have been pumped ?—No, Sir.

30912. I am under the impression that nothing can pass down the chute except what has been previously pumped ?—I think that is not a fact, Sir. It may be now, I do not know ; they have altered some of these conduits.

30913. I may be wrong, but that is my impression.

30914. (*Sir William Power.*) I have that impression too ?—I think, Sir, if you bear with me for a moment, you will find in the evidence of the City Surveyor that they can discharge by gravitation near low water.

30915. (*Colonel Harding.*) Perhaps we had better leave that point ; you have stated your impression that that may be done ; I do not think so ; but we will ascertain that from witnesses who can tell us what the facts actually are ?—If you will pardon me for one moment, Sir, the whole of the low-level storage reservoir which has contained very large volumes of sewage from time to time is filled from the main sewer before it arrives at the pump wells at all. That would be unscreened and unpumped sewage.

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30916. I will not press that point ; we will probably get the facts from some of the officials of the Corporation, but I think you would not hesitate to express an opinion, would you, that pumped sewage would be unlikely to deliver unbroken fœces ?—I imagine the fœces would be disintegrated with the action of the pump.

30917. And there is this point to be borne in mind, that besides the sewage of the 10,000 persons, coming from Messrs. Harland & Wolff's Works, and the sewage from the inhabitants on the south shore, there is the sewage coming from passing ships ?—Oh, yes.

30918. So that there are other sources from which these masses of human excrement might have been derived ?—I can only attribute it to its apparent origin, to me its most obvious apparent origin ; I cannot dogmatise, of course.

30919. It would seem that we ought to look on this matter from two points of view. You look at it from a point of view, referring mainly to the past and to the conditions of the past, do you not ?—Yes, Sir, as illustrating the actual position which has now got to be dealt with.

30920. I would be glad to have your view in regard to possible conditions of the future which perhaps do not bear upon the points that you are particularly interested in, but upon which, one would like your opinion. The float experiments that you have put before us to-day would go to show that discharge on the ebb tide would carry matters along the Victoria Channel, not crossing that Channel, until the returning waters brought the matters back again ; then there apparently is a liability to pass into the Garmoyle Channel ?—The Pool of Garmoyle, the old Channel.

30921. And as the waters continue to rise to spread the matters over the Tillysburn area ?—Yes.

30922. But if the discharge is limited to the ebb tide it is evident from the experiments that you have put before us that that sewage outflow would be carried a certain distance seawards ?—At the point of the chute ?

30923. From the mouth of the chute ?—Yes.

30924. And would return with very considerable dilution ?—That is it. The amount of dilution, according to my experience, which seems to coincide with that of Dr. Letts, is variable, On some occasions a sewage current gets scattered and dissipated in the surroundings waters ; on other occasions it undergoes an initial process of dilution and then remains tolerably constant, a stratum of water as it were being wafted about in the surrounding water but remaining at about the same degree of pollution.

30925. Then should I be right in concluding that in your opinion the evils that have arisen, have arisen because the discharge has not been limited to the ebb, and because the discharge has not been limited to the mouth of the chute ?—That is a large element in the causation of the evils which have occurred.

30926. Do you believe that, if the discharge were limited to the mouth of the chute, and were limited to certain hours of the ebb, anything like the same evil conditions would arise ?—Certainly not in the Tillysburn area, but I am inclined to believe that if you had the full sewage of the city of Belfast being discharged regularly, as you suggest, from the point of the chute, you would find the nuisance would increase very much in intensity in Cultra and Holywood.

30927. And that notwithstanding the fact that they are now withdrawing a considerable proportion of the suspended matters from the sewage ?—Yes. The amount of sewage is very great and the strength of the currents in the upper part of the Lough is not strong.

30928. I do not know whether I should be right in going to other parts of this evidence ; possibly you will postpone that till after lunch. It is interesting meanwhile to get the view of Mr. Harrison, that even if the greater part of the suspended matter be withdrawn from Belfast sewage, even if the discharge be limited to the ebb, even if the discharge be brought to the present mouth of the chute, even under those conditions, he anticipates that the Tillysburn area would be exposed to considerable evils ?—Yes, it would be very much better ; its condition would be very much better than at present, but I should anticipate an increase of the nuisance at Cultra.

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30929. (*Mr. Stafford.*) What would the nuisance be from at Cultra; would it be from sewage or would it be from *ulva* ?—The nuisance at Cultra was mainly an *ulva* nuisance; it was principally an *ulva* nuisance though they did complain of sewage.

30930. What would it be under the conditions you speak of ?—It is always difficult to prophesy, but I imagine you would get a recrudescence, an increase of the *ulva* nuisance, and that you would get a much more abundant sewage pollution than you get at present.

30931. Would that be a growth of sewage at Cultra ?—I do not quite understand.

30932. Would it be from the growth of sewage at Cultra ?—An increase of the amount ?

30933. Yes; of the growth of it. You see there are two things in the matter; there is *ulva* growing down at Cultra and there is *ulva* on the Tillysburn bank being cast on to Cultra; which of those two things would you anticipate the nuisance would arise from ?—In the prospective conditions to which you are referring ?

30934. Yes ?—*Ulva* which would grow in the shallow waters somewhere between the point of the chute and Cultra and sewage itself and such growth as takes place at Cultra; I have never discovered any great growth at Cultra.

30935. (*Colonel Harding.*) Might I ask your experience; I understand that you have known these local conditions for many years ?—Yes.

30936. And you have told us that after 1893, when the discharge, instead of passing down the Lagan was sent to the mouth of the present chute, a change took place; that the conditions at Tillysburn were improved and that the conditions at Cultra and Holywood were made worse ?—Yes, Sir.

30937. And it is precisely this last result that you foresee, if the prospective conditions I have referred to, are carried out ?—Yes.

30938. Now in that case, what was exactly the nuisance that arose at Cultra; weed was washed ashore ?—It was principally a weed nuisance.

30939. From what source was it washed ashore. Did you notice that on the Holywood bank there was any growth, any production of *ulva* at that time ?—You are referring, Sir, to the foreshore in front of Kinnegar and Holywood.

30940. You will notice that the Holywood bank stretches out to the Victoria Channel ?—Yes.

30941. And I think you suggested that the discharge at the mouth of the chute, which took place in 1893, caused a growth of *ulva* upon that bank which projects out as far as the Victoria Channel ?—No, Sir, I have never traced that growth actually on that bank.

30942. So that then the evil of Cultra was not due to growth of the Holywood bank; it was due to *ulva* being driven ashore from some other source ?—From some other source.

30943. Now from what other source ?—That is a little difficult to say, but I imagine it is in the shallower waters at and below low-water mark in the regions which were irrigated by the discharge from the chute.

30944. Well, I am rather puzzled to know how the weed nuisance could arise at Cultra if the growth of the weed had been greatly reduced at Tillysburn and if there was no growth on the Holywood Bank ?—Well, Sir, I am not able to suggest that all the weed, which was washed ashore at Cultra, was grown in the Tillysburn area.

30945. Then where do you suggest it was grown ?—In the shallow waters of the Lough.

30946. Where ?—If you will follow the lines on this plan, Sir, if you will take roughly a line from the chute to Cultra you will find very large areas of banks which are enclosed by the one fathom or the two fathom lines.

30947. But, as a fact, you do not remember seeing any growth of *ulva* on the Holywood bank at the point which stretches out to the Victoria Channel ?—No substantial quantities.

30948. You do not remember seeing any ?—No substantial quantities. And, if I might advert to the difficulty further to which you are addressing yourself as to the origin, the place of growth, of the weed which went ashore at Cultra, there has been controversy until 1907, or later as to where it actually grew. At the earlier inquiries we had charts produced by the Belfast Corporation authorities with pictures of all the outfalls on the County Down shore depicting beds of weed growing round the outfalls, evidence or suggestion which we could only meet by sending witnesses to the outfalls who were in a position to swear there were no beds of weed growing at the outfalls.

30949. You conclude then that the growth of the weed, although it may be due to sewage discharges, is dependent upon other conditions besides pollution ?—It you do not find it in the immediate neighbourhood of sewage discharges, and if you do not find it as one would be rather inclined to think one would find it, in the neighbourhood of the great discharge at the Belfast main outfall, if you do not find it under those conditions in that immediate neighbourhood of sewage discharges it is evident there are other conditions which affect its growth besides the condition of the pollution of the water. There is the quantum and the quality of the nutriment which it requires. If I might take a homely illustration, Sir, you will find plenty of vegetables and fruit and so on which undoubtedly thrive when treated with manure, but which would not grow at their best if planted in a manure heap.

30950. You mean that the discharge may be too strong locally for the development of the *ulva* ?—Yes. In the first place a copious discharge of sewage, with a considerable amount of solids, might actually smother the weed; in the second place it has not facilities for root attachment if there is only a slime coated bank and in the third place the pollution in the water, the sewage constituents in the water, might be so abundant as to almost choke the vital processes of the weed, or to deprive it of other constituents in the water which it required.

30951. You are clearly of opinion that topographical conditions, conditions which facilitate the attachment of the weed, have a very great influence upon its development ?—I think it requires probably some sort of anchorage in its earlier stages of growth.

30952. So you think, that in the study of this matter one must be guided, not only by conditions of water pollution, but by certain local conditions, topographical and other, which may favour the development of the weed ?—Yes, Sir. I think you want, for instance, to get it in a place where it gets some shelter from strong currents, where it is submerged at nearly all states of the tide, but where it gets a sufficiency of light. You will not get it in very deep water I imagine, but of course I am speaking without any expert knowledge.

30953. Do you happen to know the Victoria Park Lakes ?—Yes, I have seen them, passing by.

30954. Have you noticed a very considerable growth of *ulva* in those Lakes ?—No, Sir; I have not examined the Lakes.

30955. You have not seen men at certain seasons engaged in raking this matter to the shore ?—My attention was never directed to that.

30956. Would you be surprised to find *ulva* growing very freely under those conditions ?—I would say I would be very much surprised at it.

30957. Would you expect serious pollution in those Lakes ?—I am afraid I cannot say where the water comes from.

30958. It is sea water, let in, I believe, at regular intervals, so I understand, but it is not flowing during the intervals. The water is let out, I believe, at regular intervals and let in again from the sea. Perhaps it may be worth your attention, in connection with the study of the growth of *ulva*, that *ulva* is found there, and if you inquire into the facts, I think you will find it is found there in considerable abundance ?—I am very much obliged to you for the suggestion.

30959. There is no continuous pollution, it is only occasional pollution when the valves are open ?—The depth of water would be suitable, the spores of the weed would be present in all the water introduced, and I should imagine in water in the current of the bed a considerable amount of sewage pollution, the exact quantity I cannot state.

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30960. You would agree, would you not, that in the study of this important question, it is of vital consequence that we should ascertain whether the purification of Belfast sewage would do away with the growth of this weed ?—Well, yes and no, because the position is that we have, in our view, pollution by sewage, that the Legislature as our instance has decreed that Belfast should instal a proper system for the purification of its sewage, and I think that whatever the connection between purification and *ulva*, we are entitled to the benefit of the provision which Parliament enacted for our benefit; and I think that if that measure were adopted by the Belfast Corporation, then this Commission would be in a position to get very valuable light thrown upon the life processes of the *ulva* by seeing what will have occurred in Belfast Lough when the Belfast Sewage is purified. And, of course, on general grounds, I would suggest that where there are these enormous areas of mud banks in close proximity to large bodies of population, and where there are many estuaries, connecting with many sewers, running up into these centres of population, it is well-nigh indispensible, in the interests of the public health, as well as of the general amenities, in order to abolish nuisance, that purification should be effected.

30961. (*Chairman.*) It occurs to me we might get on faster if I were to ask you a general question ?—Will you permit me to make an explanation first. A question was asked me as to whether the outfall sewer could discharge through the chute without the sewage passing through the pumps, and I stated my impression was that evidence had been given that that was so. I can supplement that by stating that I have actually seen it doing so, as has Mr. Calwell. And I would refer you, Sir, to Q. 17249 in the Evidence given before the Belfast Health Commission :—

> 17249. (*Dr. Chalmers.*) Just one or two questions, Mr. Cutler (that is the City Surveyor) to clear up some ambiguity in my mind, regarding your answers. The outfall sewer, I understand, may discharge through the chute independently of the tank ?—Yes, at low water.
>
> 17250. At low water only ?—Yes ; some little period of low water. At low water, of course, if the tide were in connection with the sewer, it would back-water the sewer, and cause some flooding. At low water and a short period afterwards we can discharge through the chute from the sewer direct, and we do so.
>
> 17251. Then with regard to the defects in the chute, might any part of that be due to internal pressure ?—Yes, in some places the planks have been blown off tanks through pressure. We have put walings round each side.
>
> 17752. Then internal pressure assumes blocking at some part ?—There has been blocking no doubt which has accounted for the rise in some of the planks but I think in the first case the planks were lifted off probably through the sewage being let off too rapidly from the tank. The water in the tank would be considerably above the level of the tide, and if that is let off too rapidly the chute would be liable to injury, and I am afraid that did occur, though great care was exercised.
>
> 17253. That is quite apart from actual deposit ?—Yes."

I think that supports my previous answer.

30962. (*Colonel Harding.*) That is illegitimate discharge, is it not ?—An illegitimate discharge, yes.

30963. (*Chairman.*) Well, I was going to ask you generally what are your recommendations as regards what should be done ; what would you suggest that the Belfast Corporation should be advised to do ?—I must refer you to the last Chapter of the Memorandum. To put it quite briefly, Sir, firstly, that it should construct works and appliances of sufficient capacity to enable it to comply with the spirit as well as with the letter of the Main Drainage Regulations embodied in the Act of 1887. That is, that it should be in a position to deal with its sewage flow up to six dilutions, storing it at the main drainage works and to discharge it only during the first three-and a-half hours of the ebb tide, through a chute which shall have an undiminished sectional capacity, and shall be able to carry off the whole of the impounded sewage during the first three-and-a-half hours of the ebb tide.

30964. Is the tank capacity at present great enough ?—Not nearly.

30965. You would suggest to begin with that the tank capacity be enlarged ?—Yes.

30966. Would you keep the chute as it is ; I do not mean in the way of repairing it and so on, but would you have a new chute constructed ; would its point of exit be further down the Lough than the present one ?—I should suggest that the point of discharge should be further down the Lough into deeper water, but I would also suggest that the history of the chute clearly indicates that it is an impossible structure in its present form. We have had it in evidence, I do not wish to weary you by going into it in detail, that such a head as was available in the brick reservoir constructed under the Act of 1887, could not be used because, if that head were used the chute would burst. This is in accordance with the evidence of the City Surveyor given on several occasions.

30967. The present chute would burst ?—The present chute. They have had to be very careful in manipulating the valves, because it they availed themselves of anything like the full head they would blow the top off the chute, and it would discharge at the wrong end. Might I supplement my answer by also saying, in reference to the question what the Belfast Corporation should do, I would also suggest that the Belfast Corporation should comply with its other Statutory obligation and should purify its sewage prior to discharge.

30968. We will come to that a little later ?—I do not want the one to go without the other.

30969. Well, I will just sum up for the moment, that you think that the Belfast Corporation ought to enlarge the tanks, to renew the chute, make it discharge into deeper water, and also to purify the sewage first, and that the larger tanks in which they impound the sewage, before its discharge, should be at such a level as to enable the sewage to be discharged, during these hours ?—Yes.

30970. (*Sir William Power*). The whole sewage ; how many dilutions, are you thinking of the dry weather flow or how many times the dry weather flow ?—I should suggest six times the dry weather flow.

30971. (*Colonel Harding.*) Do you suggest the head they now have at their Works would be insufficient to discharge through a chute of adequate area ?—The tank which they have at present only holds 4,500,000 gallons.

30972. But if they enlarge the capacity of their tanks, keeping them at the same level, would that head be sufficient to discharge through a chute which would be of sufficient sectional area ?—My impression is that it would be so, subject to advice from the engineer.

30973. Would you like me to ask Mr. Calwell these engineering questions ? I do not know whether Mr. Calwell would agree to give his opinion in regard to an improved chute ? May I ask first, whether he thinks any kind of wooden chute would be likely to answer, or whether any improvement, modification or repair of the chute would be likely to lead to satisfactory results ?—(*Mr. Calwell.*) I do not think the present chute could be made available.

30974. Do you think any wooden chute would be available ?—No, because it would be so very unsatisfactory The life would be so short.

30975. Do you suggest, as an alternative, that the chute should be built of iron through one or more pipes or conduit ?—An iron or steel chute, Sir.

30976. I do not know whether you would care to give us any idea of what might be the dimensions of a steel pipe ?—I have not considered that.

30977. I can quite understand that you did not think you would be called upon to answer a question of that kind ?—I might mention that it was contemplated originally to put steel piping in for the chute, and that that was changed for the present structure.

30978. Which was probably a cheaper one ?—A cheaper one.

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30979. But you see, as an engineer, no difficulty in the construction of steel piping to convey the sewage from the tanks at their existing head ?—Nothing whatever.

30980. You think the existing head is sufficient ?—It is a matter of expense as to constructing a steel outlet.

30981. (*Chairman.*) Is there plenty of available ground to enlarge the tanks ?—They have about 80 acres, the Corporation have by land reclamation. The cartoon here shows the portion, but it runs up to the Midland Railway. You will see a line there "now reclaimed," that is all reclaimed; that is about 80 acres.

30982. But is that at not too low a level ?—At present it is at too low a level.

30983. It would have to be raised ?—It would have to be raised; and the present tank would have to be raised. The present tank is a brick structure with a pile foundation, and you would require to carry out some similar tank to that.

30984. How much is the present structure raised above the level of the land ?—I could give you a plan of the present structure if you care to see it, showing the chute. (*Mr. Harrison.*) The level of the sewage in the existing tank, when it is full, is about 7 feet above high-water mark, 6 to 7 feet.

30985. That disposes of that point, I think. Then we come next to the point of discharge; where do you think the point of discharge ought to be ?—The words "open channel" occur on the map. That is a channel which was originally dredged under the provisions of the Main Drainage Act, 1887. It was about a third of a mile, or rather less, and continuing in the line of the chute.

30986. Do you think the chute should go to the end of the two lines ?—I suggest in the Memorandum that it should be continued to at least the one fathom line.

30987. That is still further out ?—Yes.

30988. That is to say its length should be increased roughly by one-half ?—Very nearly; about that I should think.

30989. Then the next question you come to is the purification of the sewage. Why do you think the sewage should be purified, otherwise than by septic treatment ? Is it because of the Act of Parliament ?—Well, because of the Act of Parliament and the bargain which that Act of Parliament embodied. When the Bill was presented to Parliament by the Belfast Corporation, in 1899, there was a Petition, very influentially signed, presented against it on the ground that the existing discharge of sewage was creating a great nuisance in the Lough. The Bill sought powers for the Corporation to convert a large number of earth closets and privies in Belfast into a water-carriage system, and that involved the carrying of the sewage of a population of about 100,000 to 110,000 additional persons into the Main Drainage Works, and it was contended that if the Corporation were to be allowed to do that they should be put under terms to purify. The Petition was withdrawn as the result of a bargain made in the Lobby of the House between the Petitioners and the Corporation Officials who had charge of the Bill. The opposition to the Bill was withdrawn on that purification provision being inserted, and we have made our bargain, we have waited patiently a long time for its fulfilment, and we do not feel inclined now to waive our side of it. That is the first ground.

30990. This provision was inserted simply because it was supposed that without purification there would be nuisance. If it could be proved that purification would not prevent that nuisance, would you not think that that side of the bargain might not be adhered to ?—Parliament is, as a rule, rather slow to overrule a Parliamentary bargain of that character, and, of course, we would suggest, subject to the Report of the Royal Commission, that it is very hard to prove a negative consequence, negative in this sense, that you could assert definitely and without any possibility of error, that full purification, according to the best known standards would not diminish the existing nuisance. I make that suggestion with great respect, Sir, having regard to the authority of this Commission.

30991. Well, supposing it to be proved, which it is not at present, it looks conceivable that the filtration of sewage does not perceptibly diminish the growth of the *ulva*; that is to say that the *ulva* will grow in a sewage effluent nearly, if not quite as well or even better than it does in an unpurified sewage, which has merely been settled sewage; would it not appear a reason for at all events delaying the purification of the sewage provided other works are constructed which will convey the sewage away; I mean such works as enlarging and lengthening the chute, and also making sufficient reservoir capacity ?—And the abolition of storm overflows, Sir ?

30992. Is that possible ?—Well, the restriction of storm overflows to storm overflows in the sense in which they are referred to in your last Report. But we have had storm overflows operating which are not, in our view, legitimate storm overflows. The level of the sewage in the sewer—for instance the sewer between No. 1 and No. 2 pumping-station is a purely arbitrary level which can be created by stopping the sewer at one end and pumping at the other end. There have been, in the past, at any rate such storm overflows and there are storm overflows now designed on that sewer. They are adjustable, and we are at the mercy of subordinate officials in regard to them.

30993. But suppose the chute is sufficiently enlarged in area to take all the sewage, these storm overflows would not come into operation; there would be no need to bring them into operation ?—There is sometimes a tendency on the part of subordinate officials to save pumping expenses by opening adjustable storm overflows.

30994. And you think that this should not be possible ?—I suggest with great respect, Sir, that they should be automatic, and that they should be placed in such positions that they could only operate when the flow had attained certain proportions. I admit, especially in a place like Belfast, it may be necessary to have some means of disposing of an emergency flow of very large proportions.

30995. It appears to me that the problem is this:—It has been shown conclusively that sewage, purified or unpurified, is conducive to the growth of *ulva*; it has not been proved, but it looks probable, that *ulva* will grow as well in filtered effluent as in settled sewage. What is the advantage at present of insisting upon filtration of the sewage, after settling, when there are other things to be done which may produce the desired effect, namely, lengthening the chute and reclaiming the slob lands ?—Well, of course, as a matter of practical politics——

30996. That is what we want to be at ?—With regard to the reclamation of these lands that is something in the distant future still. There are a good many local bodies; there are Crown Rights to be considered; local bodies have to be got into agreement, all sorts of financial questions have to be considered. I do not know how far the Harbour Authorities would be willing to lose the scour which it is suggested comes from these slob lands. I know that Harbour Authorities in other places have made a good deal of difficulty about the reclamation of slob lands as losing the scour of their Channel.

30997. I do not know whether it is worth asking you whether the Victoria Park was originally Crown Land ?—I think so.

30998. Did the Crown give it to the Town ?—(*Mr. Calwell*). It was a bargain entered into with the Harbour Commissioners and the Corporation. The Corporation gave a piece of land to the harbour and they got that from the harbour in exchange.

30999. Then to ask a similar question, I notice the words, "Now reclaimed" near the Main Drainage Works; does that land "Now reclaimed" belong to the Main Drainage Works ?—(*Mr. Harrison.*) Yes, Sir.

31000. Did the Crown give up its rights to that piece of land ?—It was acquired in the later 'nineties. It was under the 1887 Act.

31001. Did the Crown give up its right ?—(*Mr. Calwell.*) There was an arbitration held, under the compulsory purchase of land.

31002. Could not the same thing be done with the Tillysburn area and the Holywood bank ?—(*Mr. Harrison.*) It would require agreement by many different public authorities. I do not say there is any insuperable difficulty, but I only suggest it would take a considerable time and we have been waiting a long time.

31003. The question is what can be done at the present moment; that is really what we want to know; what can be done within the next year, if possible ?—Of course, the means which you suggest could be carried out forthwith, no doubt. In regard to purification, as distinguished from sedimentation, I am inclined to admit that the works such as you suggest for a discharge of the whole sewage flow into Whitehouse Roads would tend to improve the position very much with regard to the Tillysburn area, especially if no discharges are allowed at Sydenham or in the neighbourhood of Sydenham, that is if the new outfall is to be a new outfall for the whole city. On the other hand, I have not been as closely identified with the agitation against the nuisance at the Cultra end of the foreshore as I have been at the Tillysburn end. The Tillysburn end, with the prevalent winds, is the one which has affected me most, and I think you would get considerable opposition on the part of the people of Holywood at the north-east end, and on the part of the people who reside at Cultra and even further down than Cultra, to a scheme which would bring this enormous discharge of sewage much nearer to them. They would say that the purification provisions of the Act of 1899 bound them and the Corporation, and if there is any likelihood or even possibility of their being seriously injured by this very large discharge of sewage into Whitehouse Roads they are entitled to rely upon the protection of the purification provisions of the Act of 1899. I think you will find that that would be the attitude of the people residing in that part of the country. And, of course, on general grounds, we all of us suggest that the upper waters of the Lough are very sluggish, and that this enormous discharge of sewage which tends year by year to increase, because Belfast is a rapidly increasing city, will inevitably tend to create a nuisance if not at the place of the previously existing nuisance, then just a little further down.

31004. Would there be much trouble in recovering the slob lands ; they do not appear to be very wide, only 150 yards or thereabouts ?—As far as that is concerned, I imagine, as an engineering operation, it is perfectly practicable. I know that the Embankment would have to be a very strong one ; the sea is very violent there at times. Unfortunately I have a sea-wall in front of Holywood which costs a great deal of money, because it gets washed away very frequently. It would be of advantage to me, the reclamation in that sense.

31005. Is it near Kinnegar Park ?—It is down on the other side ; along the front of the Town of Holywood. We have had to spend a good many thousand pounds.

31006. On keeping up the wall ?—I have had to spend about £1,500 or more in the last ten years, and the Town have also to spend money in keeping up its wall. The further you get out into deep water the stronger the embankment would have to be.

31007. Well, I do not think we have come to the question as regards purification yet. You argue in favour of it, at all events getting powers for enforcing it. It appears to me as an outsider that the Corporation if forced to spend a great deal of money in purification would be less willing to spend money on other things. Is not the first desideratum to increase the length of this chute and to renew it entirely ?—If that is coupled with the provision of a single outfall for the whole city and with the provisions of adequate tankage and at suitable level, and the abolition of illegitimate storm overflows. I put it shortly.

31008. And you would drop the purification as not of immediate importance, however important it might be at a later stage ?—I should not like to commit myself to the view that I should drop it until I am quite satisfied.

31009. Well but you could try without it to begin with ; you could postpone it at all events ?—I could only assent to that view in the event of the Royal Commission giving an authoritative pronouncement as to the thing that would ensue.

31010. That is more than the Royal Commission could undertake to do.

31011. (*Mr. Tatton.*) There is only just one question about the size of the tanks. I think you suggested that the tanks should have a capacity of six times the dry weather flow ?—Well, six are not the exact factors in the calculation I think. The chute would have to be able to carry off in three and a half hours the accumulated flow for twelve hours ; that is, the valves would have to be closed for eight and a half hours, and then while it is discharging during its legitimate three and a half hour period, the chute would also have to discharge the flow that is coming down during that period of three and a half hours, so that in all it would have to discharge a twelve hour flow, and the tankage capacity would have to be sufficient to store up the flow coming down during eight and a half hours at possibly the rate of six times the dry weather flow.

31012. Would that allow sufficient settlement, a sufficient quiescence in the tanks ?—I was speaking simply of storage apart from settlement.

31013. Quite so, apart from treatment ?—I do not profess to say at the moment—one has to cover a good deal of ground in an examination of this kind—what the tankage capacity would have to be for sedimentation, adequate sedimentation, but the tankage would have to be very largely in excess of what there is now.

31014. Could that be done without pumping ?—No ; it would require pumping. At present the storage reservoir is filled as to its lower part by a gravitation flow in the outfall sewer as it comes down, the rest of it is filled by pumping. The lower part is filled by gravitation and the upper part by pumping but to get an adequate head, such as has been already referred to with these tanks of increased capacity it would be necessary to pump.

31015. To pump into the chute into the Channel ?—To pump into your storage tanks : we would then get the requisite head to get for discharge into the chute.

31016. (*Chairman.*) Would you suggest taking the Sydenham and other sewage over to your side ; is that part of the suggestion ?—Yes, Sir.

31017. Take the whole sewage of Belfast into the Main Drainage Works ?—It might initially be rather more expensive, it would probably lead to diminished cost of working and increased efficiency in working, but we would oppose very strongly any outfall or any discharge of any effluent in the region of the Tillysburn area at all or even in the Victoria Channel. If you are going to deal with an outfall at the southern side which would be in any way comparable as to its general conditions with the outfall on the northern side you would have to carry the pipe for that southern effluent past Holywood at its deep water so as to take it out of the estuary. I do not know if I referred you to the point as to where the true mouth of the Lagan river is.

31018. I have often wondered where that is ?—Well, Sir, it is referred to in the Memorandum, I think it is in the second chapter at the bottom of p. 7 and the beginning of p. 8 and I refer there to the Belfast Harbour Acts of 1847 and 1882 as showing inferentially that the mouth of the river Lagan is at Garmoyle ; and that the facts, the physical facts were investigated in a very big law case called " Donegal *v.* Templemore " in 1858 (I give the reference to the case in a foot note) ; when the judges stated that the evidence had clearly proved that the river Lagan was identified at low water down to the pool of Garmoyle. I refer also to the lines of low water mark in the chart and the one fathom line and the two fathom lines as showing at low water that that was in effect the mouth of the river.

31019. There is no record of what the depth is inside that Garmoyle area ?—Garmoyle itself is quite deep. I have here, Sir, a chart or plan of Belfast Harbour on the 31st December, 1850 ; that is before any Victoria Channel was created and it shows rather clearly I think, where the river is at low water. You will see from that, Sir, that the curve which is marked on the plan appended to the Memorandum, the curve which comes over to the Tillysburn Area, represents the old river bed which was the navigation channel until the Victoria Channel extension, which was created in 1891.

31020. (*Sir William Power.*) It is the navigation Channel now for small vessels it is not ?—They mostly go up the Victoria Channel now which is very convenient and wide open.

31021. (*Chairman.*) Is the Musgrave Channel used or is it not ?—It is used, I think, to a certain extent.

31022. But it appears to have no exit ?—No ; it is a *cul de sac.*

31023. (*Mr. Stafford.*) Would the capacity of the existing main sewers of Belfast admit of your suggestions being

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carried out with regard to the Knock sewage and the other sewage you referred to ?—I do not quite take your question.

31024. Are the existing main sewers large enough ?—To carry six dilutions ?

31025. Yes, and to carry also the Sydenham Knock sewage ?—I think that the low level intercepting sewer which is syphoned under the Lagan has not sufficient capacity at the present time to carry the whole of the Sydenham sewage.

31026. Therefore you would have to relay the whole of your sewers ?—You would have to increase the sewer accommodation. Might I mention in passing with regard to the low level sewer which is syphoned under the Lagan that its original diameter has been reduced. I think it cracked or something of that sort and a pipe or skin of brickwork was put inside.

31027. Is not, as I understand it, the Corporation of Belfast objection to including Knock and Sydenham and also to the six dilutions being put into the sewers that they cannot possibly take it in the existing sewer, Mr. Cutler stated it in evidence at the Inquiry ?—I think it is probable the sewer is not of sufficient capacity to carry it.

31028. Therefore it would mean a duplication of the sewers or the relaying of a larger sewer than there is at present ?—It would be necessary no doubt pursuant to the Main Drainage Act, 1887, to supplement the low level intercepting sewer by such further intercepting sewer as may be necessary to carry the sewage across.

31029. Increase the sewerage in Belfast ?—It would mean an increase.

31030. Mr. Cutler put that in his evidence very clearly at the Inquiry ?—Yes, but as against that you get rid of the outfall works and pumping works at the proposed Sydenham outfall.

31031. That would be a very small thing compared with the duplication of the main intercepting sewers ?—I have no estimates of the exact cost with respect to that. I suggest there is such a thing as being penny wise and pound foolish in dealing with the sewage of a large city.

31032. That is true, but the Commission ought to be acquainted with this question and what it involves ?—I admit at once the initial expense may be greater in carrying the sewage across, but in actual working it will be less.

31033. That is the Belfast objection to including Knock and Sydenham ?—Oh ! no doubt, I understand, Sir, in that connection that the existing sewer for the existing city area is too small to carry the flow at the present time, and that even supposing it were considered legitimate regarding the added area to have a separate outfall it would be necessary for the city proper on the County Down side which by statute must be connected with the main Drainage Works, to supplement the sewer accommodation because the Corporation proposal as you are no doubt aware for a separate outfall at Sydenham involved diverting to that outfall a large volume of the sewage which has always been connected with the Main Drainage Works and which under the Main Drainage Act must necessarily be connected with the Main Drainage Works.

31034. (*Chairman.*) You would require a new Act then ?—You would require a new Act.

31035. (*Mr. Tatton.*) Have you any power under the 1887 Act to compel the Corporation to carry out their obligations as regards the treatment of sewage when you made that bargain with them ?—The 1899 Act.

31036. The 1899 Act ?—No, of course, a Parliamentary bargain becomes merged in the statute. The previous bargain is gone, but you have a statutory duty, an obligation which will be enforced by a court of law at the instance of a ratepaper or at the instance of a person who is not a ratepaper, but is subjected to a nuisance which is in any way attributable to their failure to carry out their strict duty.

31037. Are they under an Order of Court now ?—No ; not yet.

31038. They have never been ?—Not yet.

31039. Then could you not get an order against them ; could you not enforce it to make them carry out their obligation ?—Oh ! yes, it is a public secret, of course, in the course of these negotiations which have taken place between myself and the Belfast Corporation, a private and confidential document appeared in the public press, and that private and confidential document stated in terms that the three senior counsel and the junior counsel of the Belfast Corporation were unanimous in advising that if we proceeded we would get an injunction with costs against the Belfast Corporation in respect of the non-purification of their sewage. And I may add that apart from myself—and I trust you will not consider me an unreasonable person in my dealings with the Belfast Corporation—one of the local authorities, the Castlereagh Rural Council, a contributory to the Joint Foreshore Board, and so on, has been to my personal knowledge advised that they must institute proceedings against the Belfast Corporation and compel them to carry out their statutory duties, because if they do not do so they themselves will be liable at the instance of their own ratepapers to penalties in the Law Courts.

31040. (*Chairman.*) So things are likely to come to a head soon ?—The thing has dragged so long that litigation has become pressing. Mr. Calwell suggests that I should mention the nature of the obligation under the Act of 1899. The obligation under the Act of 1899 was that within three years from the passing of that Act the Corporation should construct works and appliances necessary for the proper purification of all the sewage dealt with at the main drainage works, so that the Corporation is actually in default now since the year 1902.

31041. (*Colonel Harding.*) That is to say whether the means proposed to be used would be sufficient. Who is to judge that ?—The works that are to be constructed, and the method of utilising them was to be subject to the approval of the Local Government Board for Ireland, and also the duty would be subject to the supervision of any competent court whose jurisdiction was invoked as well as the Local Government Board.

31042. And it would rest with the Local Government Board for Ireland whether this or that method proposed to be followed would be sufficient ?—Yes and no.

31043. There is no statutory obligation to do a particular thing in a particular way ?—As to purification, no ; it might be by chemical purification, or it might be by bacterial purification, but it would have to be purification as known to sanitary science.

31044. (*Chairman.*) Would mere sedimentation come under that heading ?—I think not, Sir.

31045. (*Colonel Harding.*) Unless it met with the satisfaction and approval of the Local Government Board for Ireland ?—But if the Local Government Board for Ireland approved of a system as being purification which was not in fact purification according to the accepted standards of sanitary science, then a Court of Law would say the Local Government Board's approval was not a sufficient discharge to the Belfast Corporation.

31046. I rather gathered from what you said before that the final arbiter was the Local Government Board for Ireland ; that they were to carry out the purification to the satisfaction of the Local Government Board for Ireland ?—No, not quite that. I am not a lawyer but I have been very fully advised on the law on the subject, but as I understand it, under The Belfast Corporation Act, 1899, Section 43, Sub-section (6) "The Corporation shall within three years from the passing of this Act provide works and appliances necessary for the proper purification of the sewage of the City of Belfast discharged from the system of works authorised by 'The Belfast Main Drainage Act, 1887,' and shall efficiently work the same. The system of treatment and method of putting the same into operation adopted by the Corporation shall be subject to the approval of the Local Government Board." Those are two separate conditions, but the first peremptory portion of the mandatory provision is that there shall be works for the proper purification. They have to come up to a certain standard which will satisfy the Local Government Board, but the assent of the Local Government Board does not absolve them from the obligation to construct adequate purification works. That, I think, is the legal view.

31047. (*Chairman.*) There is a loophole of escape in the word "proper." Who is to interpret the meaning of the word "proper"?—You place us in a dialectical difficulty on which I imagine that learned counsel could argue for many days; but it has been accepted generally so far and the best accepted legal opinion is that that would mean purification up to the best practicable standards which are known.

31048. I rather think we have come to the end of this subject. Have you anything further you would like to bring before us?—Well, Sir, there was one question, the contribution of the foreshore population.

31049. You mean the monetary contribution?—No; the contribution to the pollution.

31050. (*Colonel Harding.*) That is really a very important point, but I have gathered from something that you have said that from your point of view it seems scarcely worth consideration?—I should like to have an opportunity of persuading the Royal Commission if possible, that my point of view was correct.

31051. (*Chairman.*) We should be very glad to hear that?—Well, Sir, the case was made at past inquiries that the foreshore nuisance primarily was attributable to the *ulva latissima* and not to sewage, and that the foreshore population, though small in numbers as compared with the City of Belfast, contributed out of all proportion to their inferior numbers by reason of what was called the concentration of the local sewage. The concentration theory of the local sewage depended on two factors. The first was that the sewage of the Castlereagh Rural District and the Holywood Urban District was actually stronger per head of population than the sewage of the Belfast population in fact, Sir. The second branch of it was that the sewage being discharged on to the beach from several outfalls along the shore operated in a concentrated form in nourishing the *ulva latissima*.

31052. Could you tell us where the outfalls are on the beach?—The first after you leave the Belfast Municipal Boundary is that little river the Tillysburn, which, as I think I explained this morning, carries no actual sewage matter, but does betray to a certain extent a sewage origin by having a certain number of sewage bacteria in it. If you inspected that outfall you might find it in a more foul condition than my words would represent, but that would be due to its carrying the drainage of the huge heap of sewage saturated *ulva latissima* which drains into it. You see it has been collected off the foreshore and dumped on a field just inside, and it drains on into the Tillysburn river.

31053. Is that on the shore side?—Between the railway and the road. Passing east from that river which in itself carries practically no objectionable matter, no putrefactive matter, you come to the point where the reclamation bank springs out from the railway in a northerly direction. Through the bank comes the treated effluent of the military barracks, which is an effluent from a system of contact beds. There is also a land water drain to carry off ordinary flood water which might accumulate behind the reclamation bank. Passing along from that you get to the front of the Kinnegar and there is a single house which no doubt has some sort of house drainage on to the beach. Passing further, when you get to Holywood station just on the coast line opposite the station, there are a few house drains, or there were until recently; they have now been taken up by an intercepting sewer and are carried along further eastward, past the station and on the shore there from the station to the end of the word "down" on the plan, there are outfalls of the Holywood sewage. The particulars of the Holywood sewage are given in this Memorandum, and briefly I might state that the whole sewage of the population does not come down, because there are a good many earth closets still in Holywood, and a certain proportion of the Holywood sewage is diverted along that railway drain towards Tillysburn, as I explained this morning, and gets purer by natural processes before it reaches Tillysburn.

31054. (*Colonel Harding.*) What is the method of treatment of Holywood sewage?—None. The Holywood sewage, such as it is, is discharged largely into streams, a good many of them, a considerable way inland, which have not a rapid flow, and there is a process of natural sedimentation.

31055. (*Chairman.*) In the streams?—To a certain extent, natural purification before it is discharged on the beach. Next after that, Sir, there is a little stream which you will see noted on the map which has some trifling evidence of bacterial contamination, but is clear and carries no observable suspended matter to the ordinary eye creating a nuisance. There may be one or two house drains. You get on till you get to Cultra and at Cultra there is a septic tank, I think it is, with the treatment of, I think, the bulk of the population there, at any rate, it accommodates the sewage of some 300 or 400 people.

31056. Is it treated after it passes the septic tank?—That I cannot say. It is treated in some way. There is a local landowner there who is looking after his interests in that locality. I do not devote so much attention to it. The theory as to the dis-proportionate contribution by these local outfalls to the causation of the nuisance depended on the high portion of nitrogenous matter which was alleged to be present in the local sewage and that this operated with concentrated effect, because the weed grew on the shore and then sewage was discharged over it.

31057. (*Sir William Power.*) What is the estimated total bulk of the sewage that comes from these various places. Is there any estimate made of what is its proportion to that that Belfast itself is discharging into the Lough. Have you any estimate of that?—The total population in that section of the rural district which, owing to the levels, could discharge down to the sea, and the total population of Holywood combined is about 6,700 persons. Holywood has a population of about 4,000; the rural district would be responsible for the balance. The rural district, however, has no sewers whatsoever. The only portion of its sewage which could reach any of these outfalls would be sewage carried down streams which would be mostly purified and rendered unobjectionable before it reached the shore at all, before it could come so far.

31058. Is there a public water supply to these populations that discharge on the foreshore?—In Holywood there is, and as against that population also the inhabitants of the military barracks represent some average of 600 persons and their sewage is treated. Well, Sir, if the sewage from the local outfalls operates in concentrated quality, you will observe that it comes from several minor outfalls and must be small in amount. If it operates in concentrated quality you would expect to find the result in the weed which was fertilized by this flow within virtually a stone's throw of the outfall, but you do not find it. If, on the other hand, it is carried to the beds where the weed does grow adjoining low-water mark, it can only reach that point by being carried by tidal waters of large amount, and it would be very largely diluted before it got there, enormously diluted. As to the other part of the case that the sewage of the locality is unduly rich in objectionable compounds, I can only say that I have seen no affirmative evidence at all, but the point has been put forward, and as a result of a tentative calculation based on assumed figures by Dr. Letts. I think it only right to refer to the point as it was put before Parliament in 1905 in Dr. Lett's evidence; and the suggestion is that two and a half foreshore residents produce as much polluted matter as seven Belfast citizens, and the suggestion seems to me to be somewhat paradoxical, and as I say there have been no observations of the character and quality of Holywood sewage to justify it, and the initial probabilities are against it. Of the total population of about 4,000 persons in Holywood, some eight hundred spend every day of their lives, except Sundays, in Belfast at work. On the other hand, the day population of Belfast is swollen above its census level by a very large influx of people who go there every day to do their business, and all the sewage from markets and trade effluents and discharges and so on, which would make the initial probability go to show that per head of population the Belfast sewage is richer in nitrogenous compounds than the local sewage. I am afraid, Sir, I have detained you rather at some length, but there is a certain amount of local feeling at what people rather considered a slight.

31059. (*Colonel Harding.*) The Holywood sewage is not treated at all?—The Holywood sewage, the Barrack sewage is treated and some of the Cultra sewage.

31060. Does the treatment of the Cultra sewage do much good, do you think? You say it is passed through

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a septic tank; is there any material improvement ?—I imagine, Sir, it at least removes the bulk of the solids, but I am not in a position to offer any further information than that I believe Dr. Letts has made several observations.

31061. Have you witnessed the outfall of the Barrack sewage ?—Yes.

31062. Have you seen it yourself ?—I have frequently.

31063. And do you consider it to be adequately purified? —I should like it to be better purified.

31064. Would that amount of purification satisfy you for Belfast ?—No, Sir.

31065. Did it seem to you to have passed through filter beds at all ?—Well, it seemed to have been altered; it did not seem to be crude sewage.

31066. Did you see any paper about ?—No; but might I just mention in that connection that one does see at various parts on the beach weed which in a particular stage of its decomposition very much resembles closet paper. I know when Professor M'Weeney visited the shore with me he at first thought he was finding closet paper until we found it was the weed in a sort of bleached condition.

31067. You made rather an interesting suggestion that the sewage of Holywood travelling for about half a mile along a stream would deposit in the course of such movement the greater part of its solids, and by natural processes of purification would reach the shore in an unobjectionable condition ?—Yes.

31068. Now, how is it, if a travel of half a mile in that way obtains purification which is sufficiently good that the Belfast sewage travelling out to sea a mile and coming back again, it is about a mile, may not also be considerably purified, and may not also have left behind it the greater part of its suspended matter ?—It is a question to a great extent of volume and the conditions as to light and air. I was suggesting that a stream, as a series of pools, will no doubt tend to capture a good deal of suspended matter, and that the longer the sewage takes in getting from pool to pool down to the outfall, the more it would have been subjected to ordinary purification processes by the atmosphere. Very large volumes of sewage on the other hand discharged into sea water, as I think I explained, undergo a certain initial dilution, and then, in the absence of any great disturbance of the water, continue in that state of dilution for sometimes a long time. The longer it is in sea water naturally the more the solids are deposited.

31069. And you think that Holywood really is not making any contribution to this evil at all ?—Well, so far as my observation goes there is a direct tidal flow from Holywood towards the lighthouse. It is rather a lateral flow the current takes that way; I do not think it comes back on to that beach; and to support what after all, is a mere opinion——

31070. Is not that what happens in the Belfast main outfall; it is taken out and then brought back again. If this is taken out and then brought back again is it not likely to produce precisely similar evils ?—I do not think there is any evidence that the Holywood sewage does come back. I was to support the opinion, which after all is only my own opinion, by referring you to what was the fact in the early eighties, when the population of Holywood was the same virtually as it is now, within 150 or 200, and when there was a water supply as there is now; there was no nuisance at Holywood; people used to bathe at Holywood.

31071. (*Sir William Power.*) Is the discharge from Holywood limited to the first half of the ebb ?—No, it dribbles on to the beach at any stage. Around the principal outfall there is a clearly marked nuisance. The whole area of it would not cover a stone's throw, not more than a stone's throw, you do not see any real deposit.

31072. (*Colonel Harding.*) Is there not some part of the Belfast population discharging near the Musgrave Channel, or into the Connswater at the present time ?—There is a discharge at Sydenham Station.

31073. The sewage of that district is not all carried across the Lagan to the main outfall ?—No.

31074. Some part of it falls into the Lough here (*Indicating*) ?—There is a little of it going into the Connswater.

31075. From how many thousands of people ?—No thousands of people into the Connswater. The Connswater in the summer is a river that could be contained in a 9-inch pipe, sewage and all; that is apart from tidal water.

31076. Have you any experience of the condition of the bed of the Connswater at low-water ?—No, Mr. Calwell has.

31077. I would like to ask Mr. Calwell what is the condition of the bed of the stream at low-water ?—(*Mr. Calwell.*) The Connswater bed, of course, at present, has a heavy deposit of dark mud; there is no doubt of that.

31078. Have you seen sewage fungus in any abundance in it ?—Yes. There is no doubt there is sewage, but that arises from the discharge from what is known as the Knock Valley Sewer, where an overflow exists where it crosses the Connswater River, and that seems to work in all conditions of the weather; it is not one that is limited to the six times the dry weather flow.

31079. Then you agree that the Connswater at the present time does bring down a considerable quantity of impurities ?—Yes, from that sewer, from the Knock Valley Sewer.

31080. Is not the discharge of the Connswater immediately in front of the nursery of the *ulva*, namely, the Tillysburn bank ?—Yes, it runs into the Musgrave Channel there.

31081. So that those impurities would reach the *ulva* banks in a somewhat undiluted form ?—They would. The Connswater, as a river, has a very small drainage area, and it is really principally a tidal river, and a large quantity of sewage enters the Connswater River by the inflowing tide from the polluted areas, created by the main drainage scheme in the Lough; and it gets a large amount of its sewage in that way, and also from this Knock Valley sewer, but there is very little sewage discharged into the Connswater River.

31082. Is there not a distillery on that stream, an important one ?—There is, but these distilleries, I understand, discharge into the main drainage system.

31083. Have you any personal knowledge of their arrangements ?—Yes, the Irish distillery discharges into the main drainage system, and I understand from Mr. Cutler that the corporation determined that the other discharges also. The Report of his evidence we have here. If you turn that up you will see both those distilleries discharge into the main drainage system.

31084. You do concede, do you not, that the Connswater brings down considerable impurities at the present moment, and that its discharge is immediately in front of the nursery ?—I would like to put it in this way, it brings up and down large quantities of sewage, because the inflowing tide carries a large amount up the river, the ebbing tide carries that down and also down the overflow from the Knock Valley sewers.

31085. And the long and the short of it is that there is local pollution ?—Oh, there is undoubtedly.

31086. And local pollution which is at a short distance from the main nurseries of the *ulva* ?—Close to where the *ulva* nurseries are.

31087. In the event of there being absolute purification of the Belfast sewage these evils would still remain ?—Well, I would not go that length, because if you avoided discharging sewage into the Lough, then it could not get up the Connswater River during the inflowing tide. By doing that you will take away a large amount of the sewage which flows both up and down the Connswater River.

31088. But you do not suggest that the Connswater River merely delivers pollutions which have been brought up to it ?—Not altogether.

31089. From the other side of the Victoria Channel ?—Not altogether, but it does take a large amount up which you can see, on observing the tidal flow of the river, but it also takes a large amount down from this Knock Valley sewer.

31090. (*Sir William Power.*) Is the Connswater practically tidal throughout its extent ?—A tidal river. If you take the tidal water out of the Connswater River, and leave only the dry weather flow you have a very small river.

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31091. The inland water coming down bears a small proportion to the sewage and other liquids that get in ?—Oh, very small. The tidal portion of the Connswater River ends at the Owen O'Cork Mill ; you see there is a weir across there where they preserve the fresh water and in dry weather there is a very small flow ; a 9-inch pipe would take the whole of the flow.

31092. (*Mr. Stafford.*) And what is your authority for thinking sewage matter is brought up the Connswater ?—Observation.

31093. Have you made any scientific experiments or analyses of the water ?—No, none ; just by sight. Well, of course, I am not a chemist.

31094. Is it not rather rash to decide off-hand, simply by sight, about these pollutions ?—Well, the Ropework Company are clients of mine and I have frequent occasion to go up the Connswater River and to make observations in connection with it, and that gave me opportunities of seeing what was going on in the Connswater. Then that Knock Valley sewer, from the very date at which it was constructed was always giving trouble, where it crossed the Connswater River. In fact it is a sewer that is not capable of taking all the sewage that goes into it and the Corporation have to discharge it frequently at storm overflow when it should not have been discharged.

31095. Do you know of any analyses made by anybody which will go to show that this Connswater River is polluted from matter coming in from the sea ?—No analyses ; only from observation.

31096. (*Colonel Harding.*) Then, may I put it to you, have you not a sample of the water that comes in and flows up with the tide into the Connswater actually to be seen any day in the Victoria Park ; the valve opens there and lets in the water which is flowing into the Connswater ; you have there a sample of it ?—Yes, the water would be pretty much the same there.

31097. So the evidence of serious pollution there is certainly not striking ?—Well, the Connswater, by the millowners there, was, at one time, considered very suitable for condensing purposes.

31098. I do not wonder ?—The Ropework Company have stopped using the water there, except by condensing with the salt water.

31099. And you yourself told us just now that there was abundant sewage fungus in the bed of the Connswater ?—Yes.

31100. You do not suggest that that sewage fungus is due to impurities brought up from the Lough ?—There is a large quantity of sewage in the Lough.

31101. Do you find sewage fungus in Victoria Park ?—I have not examined Victoria Park. Of course, as to the water in Victoria Park, the Corporation could select the day and time at which they would take that water from the river or Tillysburn District, but they could select the time, and I have no doubt they would take it when the water was in the purest condition.

31102. But the discharge from the main outfall is a daily discharge ; I do not see that any selection can be made. If it is alleged that the impurity is due to the discharge from the main outfall, I do not see that the selection of one day sooner than another would assist inasmuch as the Belfast discharge is a daily discharge ?—Of course, it is ; it is daily. I am really not aware where they get the water into the Victoria Park from.

31103. (*Mr. Stafford.*) Would you be surprised to hear that analyses of waters in that particular district have shown that they were amongst the purest in the whole Lough ?—In the Connswater River ?

31104. Yes ; the waters coming up in that part of the Lough were much the purest ?—The bights are certainly very dirty ; I think that strikes anyone who has inspected the Connswater River.

31105. (*Colonel Harding.*) I think that is agreed ?—Yes.

31106. The point upon which we are inclined to differ is that these impurities are largely due to what comes up the Connswater River instead of what goes down ?—It would depend on the time of the day that the samples were taken as to the result of the water. (*Mr. Harrison.*) If I might venture to make a suggestion, Sir ; personal observation will show that when the levels are low the stream flowing in those channels is extremely foul and turbid, and when the tide is high there is fresh tidal water which has come in and rendered the surface water much less objectionable. It is in the lower stages of the tide that you get these streams so foul.

31107. In the lower stages, then it is not the water which is coming up from seaward ; it is the water coming down the stream ?—At the lower stages of the falling tide as well as the lower stages of the flowing tide, Sir, with great respect.

31108. I suppose we may take it that this fact is acknowledged, is it not, that there are certain local discharges independent of the main discharges of the Belfast Corporation, and that whatever purification was brought about at the main outfall would not affect those local discharges unless they also were similarly purified ?—Oh, of course, they would have to be treated, Sir, they would need to be dealt with.

31109. (*Chairman.*) Just one more question ; nothing whatever has been said about the deposits on the north side of the Lough ; are they of no importance ; does practically no *ulva* grow on the slob lands on the north side of the river ?—There have been complaints from time to time of the river there. I do not pretend to have anything like the same amount of knowledge of that side as of the County Down side. I heard at one time that the nuisance was diminishing there, and at another that it was very bad indeed, but I do not profess to have any personal knowledge. In regard to Colonel Harding's question as to pollutions on the Connswater, I would refer him to the evidence which was given at the Local Government Board Inquiry in 1908. He will find there that evidence was given by Mr. John George Zachary, the chief assistant in the Works Department, and he states at questions 18247 onwards that the distillery discharges went into the sewers and not into the river.

31110. (*Colonel Harding.*) I remember that that was stated. Of course, in our view, the Connswater contributes its quota of pollution, but not a very large quota.

31111. On the other hand, there was evidence, I forget by whom at the moment, that the condition of the Connswater was especially bad, and that there are all kinds of discharges into the Connswater ?—Yes, Sir, but the whole of that corner of the Tillysburn area, including the bed of the Silver Stream, and the Musgrave Channel down to the points of the Twin Islands, are all extremely offensive deposits. The evidence of the harbour engineer was that although the Musgrave Channel has only been comparatively recently formed it is necessary for them to dredge, and they have dredged sewage matter from the Channel.

31112. (*Sir William Power.*) Should you say that these pollutions of the upper reaches of the Connswater are less or more now than ten years ago ?—I cannot, speaking from personal experience ; I was not very much interested in sewage questions ten years ago. (*Mr. Calwell.*) If I may answer that question, I would say they are less now.

31113. The pollutions in the higher reaches of the Connswater all flow from sewage or distilleries, if any ; can you tell us whether those pollutions are greater or less now than they were ten years ago ?—They are less now.

31114. (*Colonel Harding.*) What are your reasons for thinking so ?—The Rope Company put up reclamation walls on each side of the Connswater ; during that period the Connswater there was exceedingly foul, much worse than it is now. Then, of course, there was a large amount of sewage that came into that river before the Knock Valley Works were constructed. That is all taken out of it, except what takes place in these overflows. There is a decided improvement in the Connswater River in later years.

31115. (*Mr. Stafford.*) Do you remember, before they intercepted the sewage at Belfast ?—Yes.

31116. The Lagan river was in a very offensive condition ?—Very offensive.

31117. Can you show us on the map where the Lagan river then discharged ?—The sewage of the city of Belfast was discharged at several points along the Lagan. Going up the stream there was Cook Street ; there was a

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sewer there, constructed when the Central Railway was constructed. That took a large area of the city of Belfast including the union workhouse and all that district. That came down and was discharged at Cook Street, just about nearly opposite to the Victoria Park. Then of course above that there are two smaller, but nothing of any magnitude. Then as you came down you got to sewers discharging the whole way down along the Lagan and by Ferry Steps, at the continuation of High Street, there was a large sewer which discharged and also further down; it went down as far as the Harbour Commissioners.

31118. Where did that find its way, do you suppose; on to the foreshore ?—Well, in the early days before the Corporation constructed their main drainage outfall works, that found its way on to the banks of the Lagan and into this Tillysburn area. As time went on the Tillysburn area commenced to be affected.

31119. At that time was there much *ulva* growing on the Tillysburn area ?—Nothing compared to what we get now.

31120. Was that at the time when the whole sewage of Belfast, absolutely unpurified, was discharging upon that bank ?—Yes. In the River Lagan there was no *ulva* to be found at all and where the bridge crossed the river the condition was something terrible on a warm day.

31121. Then the great growth of *ulva* apparently came after the construction of the new works and the chute and the discharge at a different place ?—And *ulva* then increased in the Lough, yes. Being in the Corporation, at the time, I took an interest in it. It took about three years before it commenced to show the benefit of what was then done in the construction of the main drainage works; it took about three years before you could say the banks were, comparatively speaking, clean.

31122. So long as the concentrated sewage of Belfast was flowing on to this Tillysburn area you had no *ulva ?*—Oh, there was *ulva*, a little *ulva*.

31123. There was no nuisance at all from *ulva ?*—No; it was then what you might call a pure sewage nuisance; the nuisance did not arise from the *ulva*.

31124. At that time ?—It was considered the same nuisance that was found on the banks of the Lagan.

31125. That would go to show that the *ulva* could not grow very well in a place where there is a large amount of sewage ?—Take the present chute, you get no trace of it there; the wooden chute, you would get no *ulva* down there, because it could not simply exist; it would be smothered. No *ulva is* found close to the timber chute in the Lough, and no *ulva* was to be found on the banks of the Lagan when the Lagan was in a very impure condition, before the chute was constructed.

31126. (*Colonel Harding.*) But you said something about the *ulva* being smothered by the mud in the neighbourhood of the chute ?—That would be my own theory about it; that the cause of getting no *ulva* near the chute is that it is smothered by the deposits that take place.

31127. Then, can you explain to us why it is not smothered by the deposits on the Tillysburn Bank ?—Where you get the currents neutralising each other, and where the deposit is heavy, I do not think you will find any over there.

31128. Have we not been told there is a great deal of black mud on the Tillysburn Bank ?—Yes, but not anything like what you have on the chute, and there is not such a thing as a stone or a mussel there.

31129. Now you are coming to the point I wanted to get at; is there not something else besides mud; is not some anchorage required which is not found in the neighbourhood of the chute ?—Yes, you require an anchorage and you will not get that at the chute.

31130. So that on the Tillysburn Bank there are special conditions which favour the growth apart from the mud ?—Yes, there is. (*Mr. Harrison.*) You asked me one question, Sir William Ramsay, as to a note in that Memorandum of my evidence. You referred to the word "inconclusive" which I applied to certain observations of Professor Letts.

31131. (*Chairman.*) Yes, I did; I did not quite understand the sentence; it appeared to me to be self-contradictory ?—What I meant to represent was this, that the float experiments of Professor Letts were consistent with the tendencies of tide and current which we had observed, but that in so far as his results shown on the charts are concerned, many of these represented specimens of pollution at fixed spots without any evidence as to how that pollution was arrived at. That was taken, though it was used in evidence on certain occasions to show the origin of that pollution, to show that the origin of that pollution was to be attributed to the local discharges rather than to Belfast sewages, and it is in that connection I used the word "inconclusive," because to find sewage pollution at a particular spot gives you no indication where it has come from. The point under discussion is, from what source does it come; it is inconclusive in that sense.

31132. That makes it quite clear, thank you. We are very much obliged to you, Gentlemen, for coming and giving us the benefit of your experience.—I hope I have not wearied the Commission; I am very much obliged.

31133. We hope some remedy may be found ultimately. —I may mention with regard to our float experiments that Mr. Calwell fixed them by the use of the sextant and they are very accurately determined.

Float Experiments by Mr. HENRY HARRISON and Mr. R. I. CALWELL, C.E.

Float No. 1.

18th September, 1907.

	Morning.	Evening.	
High Water	7.25	8.1	Wind South West. Faint Wind.
Low Water	1.43 p.m.		
Mean Tide	10.34 a.m.		

This float was placed in the water at end of chute at 10.14 a.m.
This float was at point D at 11.49 a.m.
,, ,, ,, E ,, 1.12 p.m.
,, ,, ,, F ,, 1.45 ,,
,, ,, ,, G ,, 4.24 ,,

Float No. 2.

18th September, 1907.

	Morning.	Evening.	
High Water	7.25	8.1	Wind South West. Faint Wind.
Low Water	1.43 p.m.		
Mean Tide	10.34 a.m.		

This float was placed in water at end of chute at 10.16 a.m.
This float was at point C at 11.42 a.m.
,, ,, ,, D ,, 1.22 p.m.
,, ,, ,, E ,, 1.49 ,,
,, ,, ,, F ,, 4.32 ,,

Float No. 3.

18th September, 1907.

	Morning.	Evening.	
High Water	7.25	8.1	Wind South West. Faint Wind.
Low Water	1.43 p.m.		
Mean Tide	10.34 a.m.		

This float was placed in water after bank of Seal Channel basin was showing at 10 30 a.m.
This float was at point A at 12.26 p.m.
,, ,, ,, B ,, 2.41 ,,

Float No. 4.

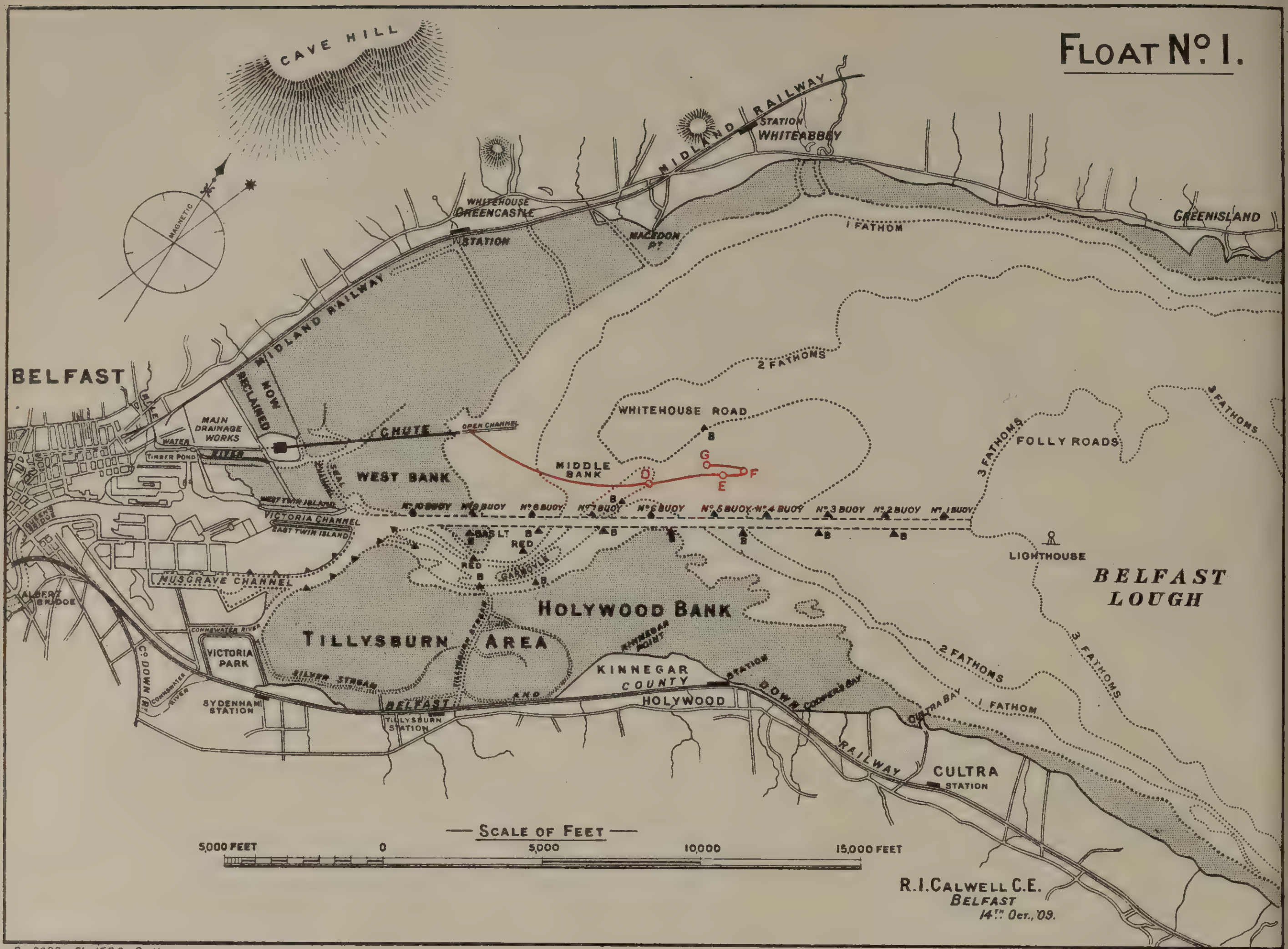
18th September, 1907.

	Morning.	Evening.	
High Water	7.25	8.1	Wind South West. Faint Wind.
Low Water	1.43 p.m.		
Mean Tide	10.34 a.m.		

This float was placed in the water in mouth of Seal Channel at a point 200 feet west of north end of West Twin Island at 11.3 a.m.
This float was at point A at 12.31 p.m.
,, ,, ,, B ,, 2.23 ,,
,, ,, ,, C ,, 3.37 ,,

[*To follow page* 20.

CHARTS ILLUSTRATING FLOAT EXPERIMENT



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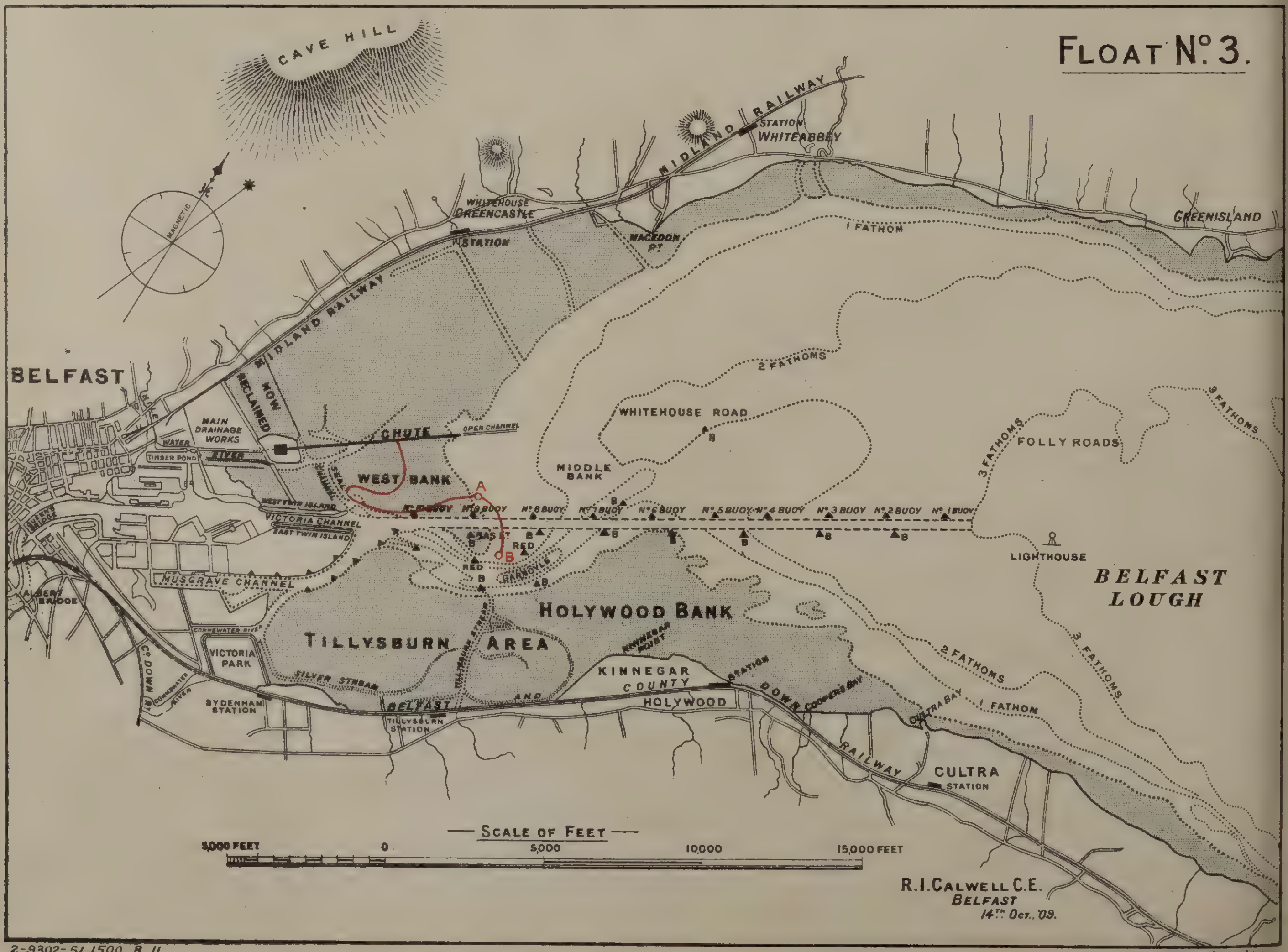

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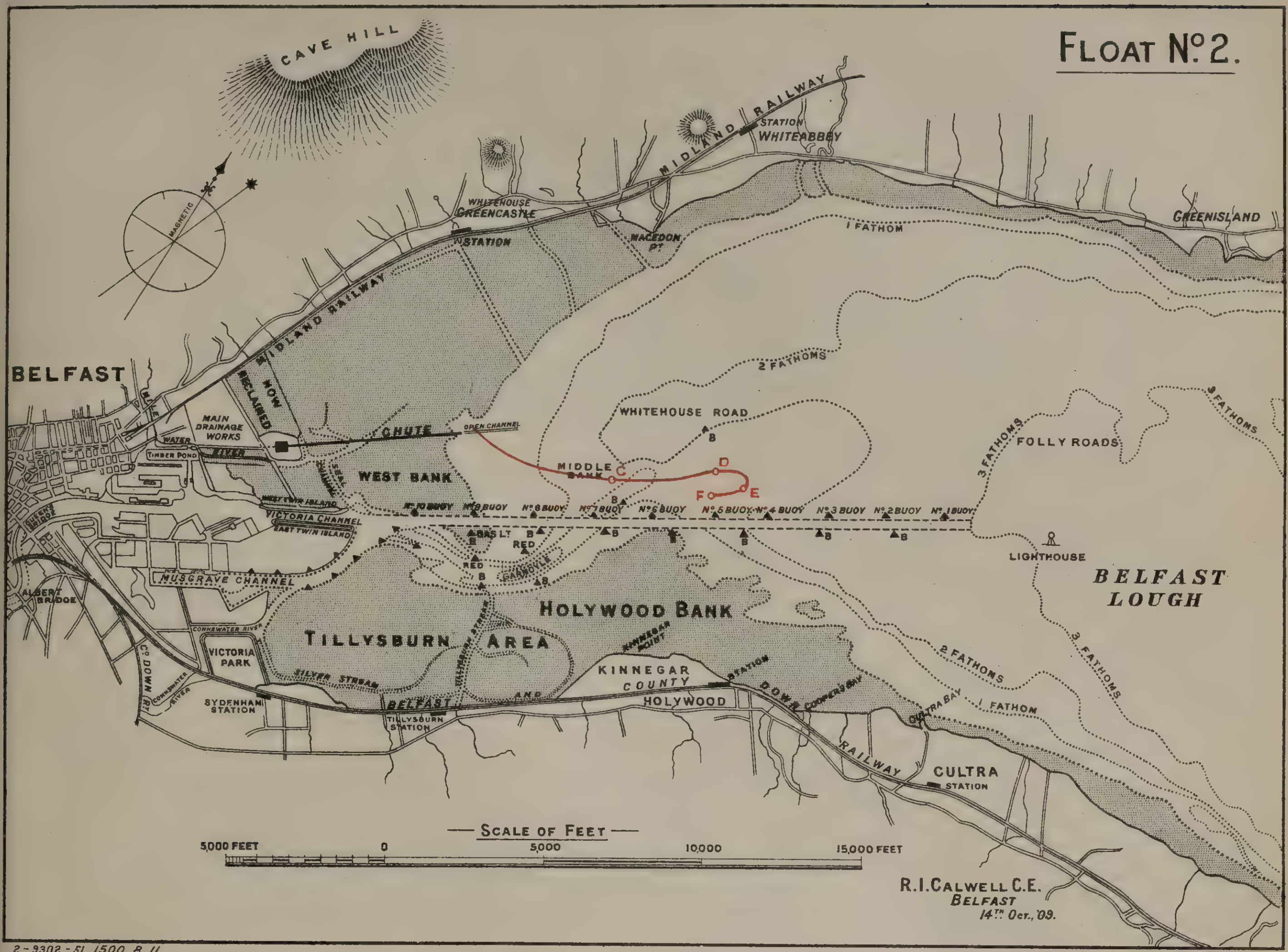
ENRY HARRISON AND MR R.I.CALWELL, C.E. A.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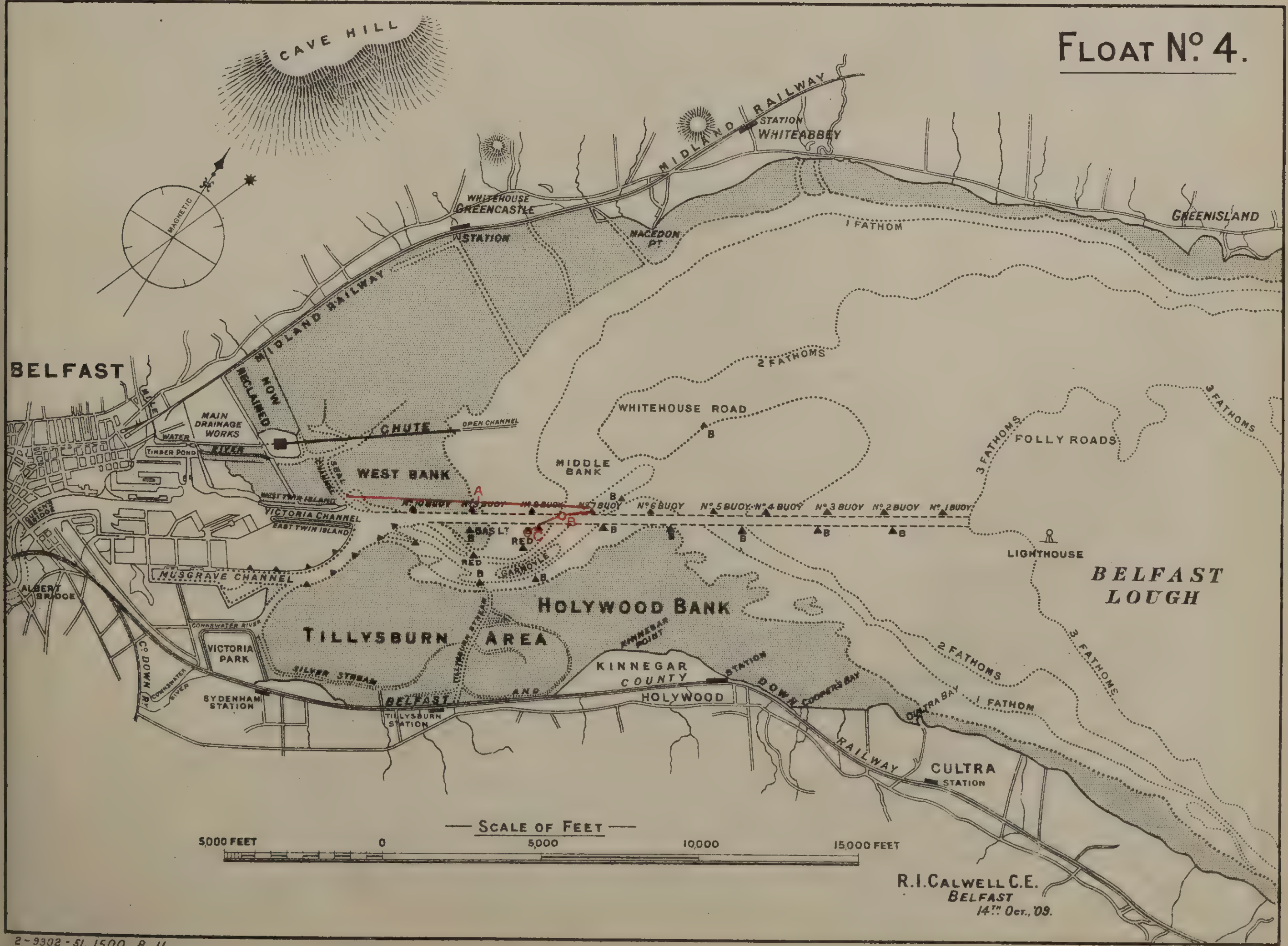

FLOAT No 4.

2-9302-51. 1500. 8.11.

Malby & Sons, Lith.

Float No. 5.

18th September, 1907.

	Morning.	Evening.	
High Water	7.25	8.1	Wind South West. Faint Wind.
Low Water	1.43 p.m.		
Mean Tide	10.34 a.m.		

This float was placed in water in line with 8th Buoy at point B at 11.30 a.m.

This float was at point C at 1. 0 p.m.
" " " D " 1.56 "
" " " E " 4. 8 "
" " " F " 4.55 "
" " " G " 6. 3 "

Float No. 6.

19th July, 1907.

	Morning.	Evening.	
High Water	8.31	8.58	Wind South East.
Low Water	2.44 p.m.		
Mean Tide	11.38 a.m.		

This float was placed in water at chute at 10.43 a.m.

This float was at point A at 11.12 a.m.
" " " B " 2.26 p.m.
" " " C " 3.10 " when it was taken out of water.

Float No. 7.

19th July, 1907.

	Morning.	Evening.	
High Water	8.31	8.58	Wind South East.
Low Water	2.44 p.m.		
Mean Tide	11.38 a.m.		

This float was placed in the water in Seal Channel at 12.23 p.m.

Float No. 8.

19th July, 1907.

	Morning.	Evening.	
High Water	8.31	8.58	Wind South East.
Low Water	2.44 p.m.		
Mean Tide	11.38 a.m.		

This float was placed in water at chute at 11.53 a.m.

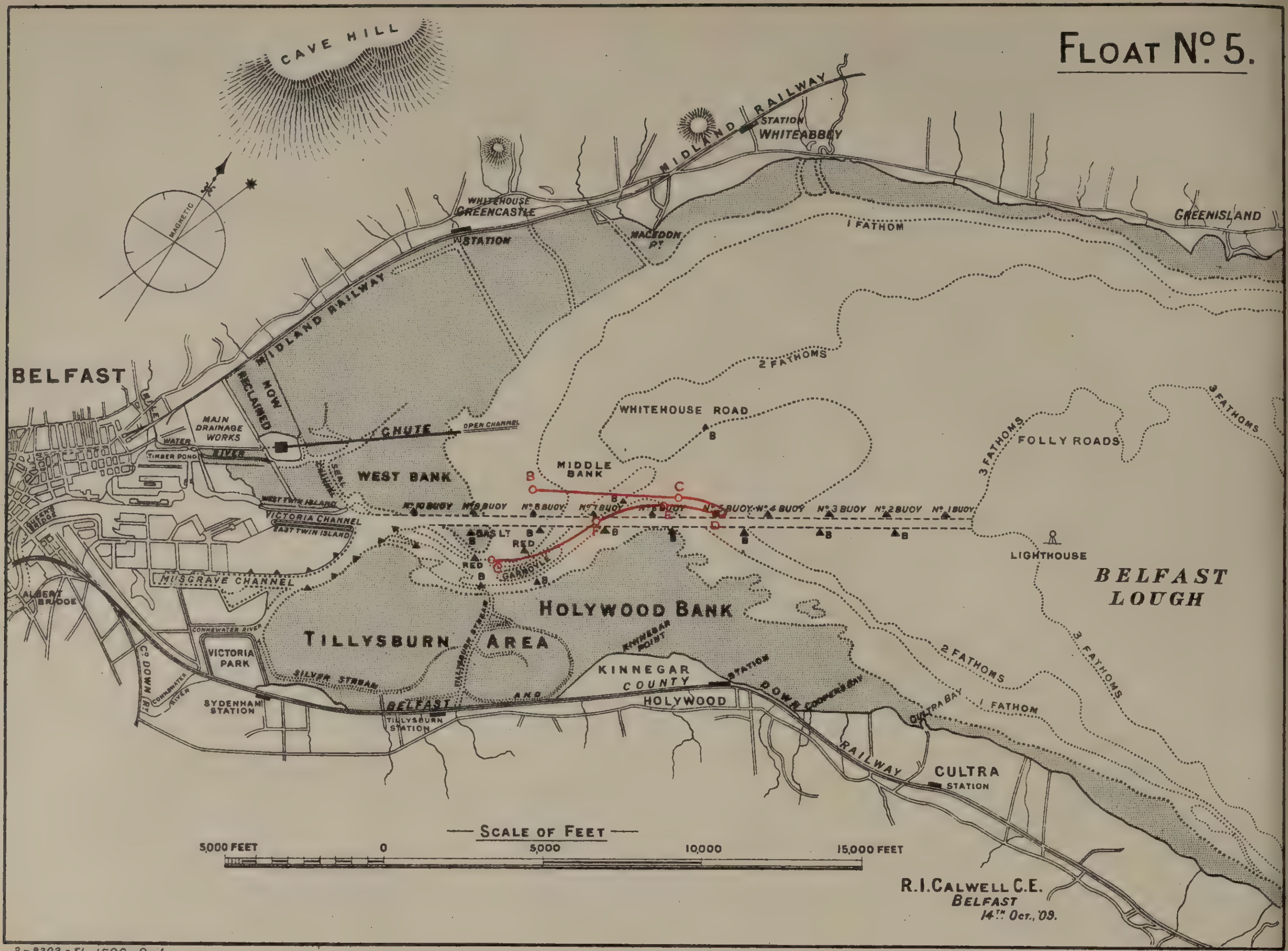
This float was at point A at 1. 7 p.m.
" " " B " 4.27 "
" " " C " 4.40 "

County Down Slob Inside City	427	acres.
Outside "	740	"
	1,167	"
County Antrim Slob Inside City	690	acres.
Outside "	731	"
	1,421	"

[*To follow page* 20A.

CHARTS ILLUSTRATING FLOAT EXPERIMENT

FLOAT No. 5.



R. I. CALWELL C.E.
BELFAST
14th Ocr., '09.

2-9302-51. 1500. 8.11.

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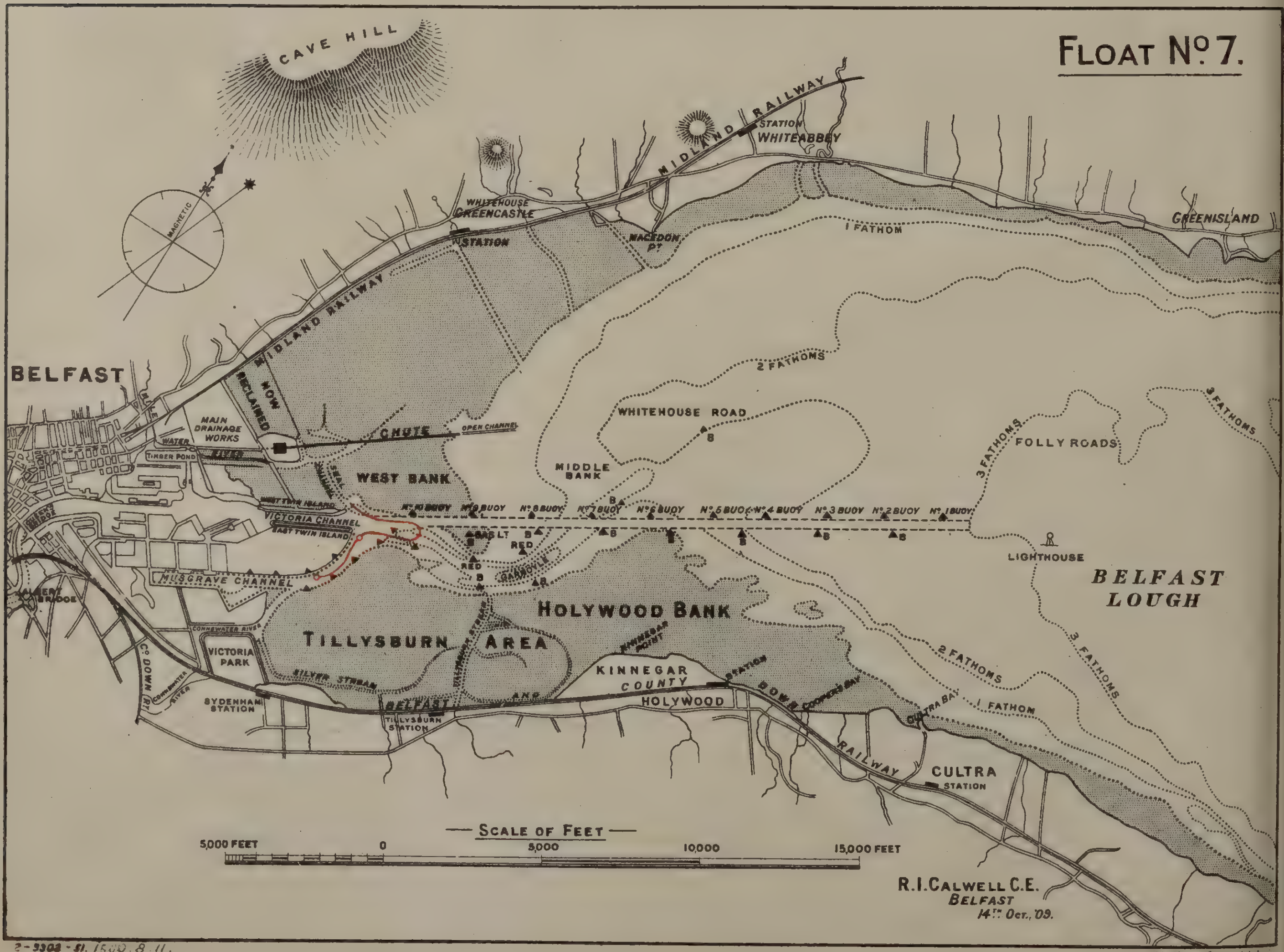
FLOAT No. 7.



R. I. CALWELL C.E.
BELFAST
14th Ocr., '09.

2-9302-51. 1500. 8.11.

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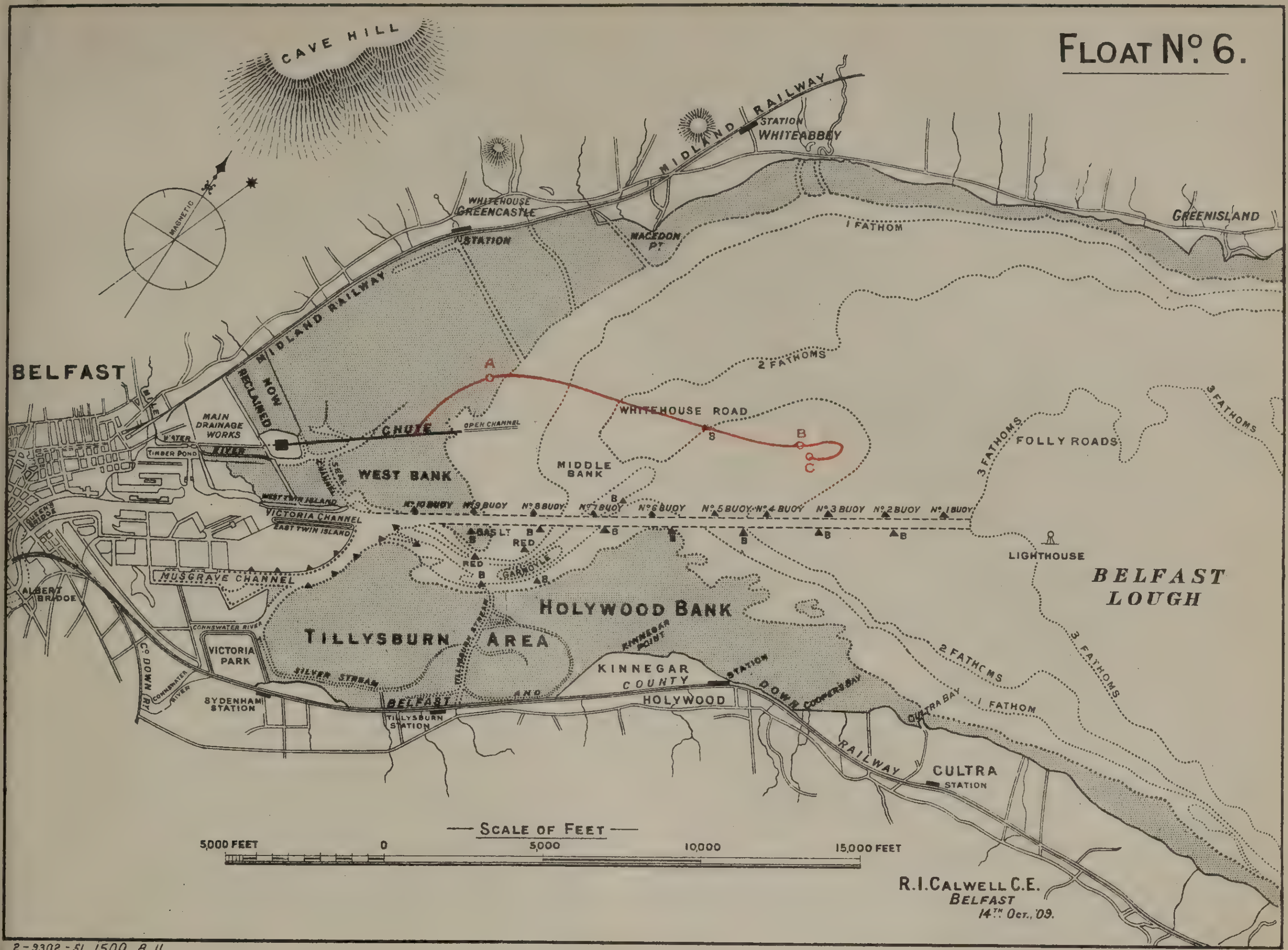
NRY HARRISON AND Mr R.I. CALWELL, C.E. B.



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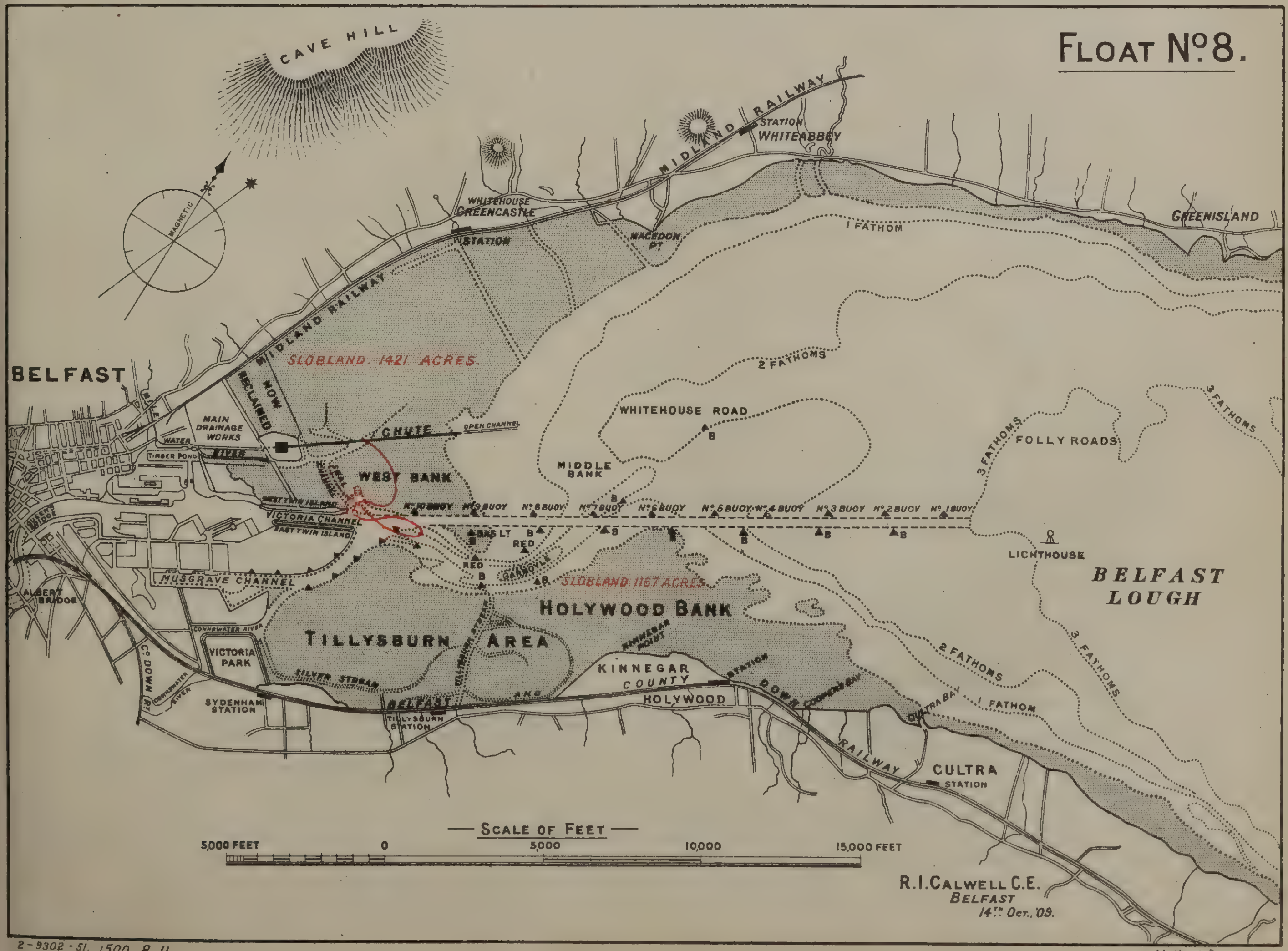

2-9302-51. 1500. 8. 11.

Malby & Sons, Lith.

NINETY-EIGHTH DAY.

Wednesday, 16th February, 1910.

PRESENT :

Sir William Ramsay, K.C.B., F.R.S. (*in the Chair*).
Colonel T. W. Harding, J.P., D.L.
Sir William H. Power, K.C.B., F.R.S.
Mr. T. J. Stafford, C.B., F.R.C.S.I.
Mr. R. A. Tatton, M. Inst. C.E.
Mr. F. J. Willis (*Secretary*).

ALSO PRESENT :

Dr. George McGowan.
Mr. G. B. Kershaw.
Mr. C. C. Frye.
Professor E. A. Letts.
Mr. E. H. Richards.

Alderman J. King Kerr, M.D., J.P., Chairman of the Public Health Committee ; Councillor Crawford McCullagh, Chairman of the Improvement Committee ; Mr. H. A. Cutler, M. Inst. C.E., City Surveyor ; Mr. W. E. Adeney, D.Sc., F.I.C., F.C.S. ; and Mr. John Hawthorne, B.A., Ph.D., representing the Corporation of Belfast, called in ; and Examined.

Alderman J. King Kerr, M.D., J.P., Councillor Crawford McCullagh, Mr. H. A. Cutler, M.Inst. C.E. Mr. W. E. Adeney, D.Sc., F.I.C., F.C.S., and Mr. John Hawthorne, B.A., Ph.D.

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31134. (*Chairman.*) I am afraid we are under some disadvantage to-day in having received the notes of evidence so late that you must excuse us if our questions are not quite pertinent. We are much obliged to you gentlemen for coming.—(*Dr. Adeney.*) I am sorry mine was late, but I thought it had been sent on to you.

31135. There are certain things, I think, that we may take for granted; things which we are all agreed upon: that Belfast Lough is very much polluted with *ulva*, that it was not so polluted in old times, and that this *ulva* flourishes in nitrogeneous liquids, liquids containing ammonia, nitrate and nitrates. I think we can all begin by taking that for granted. Now, I presume, Mr. Cutler would like to be examined first ?—(*Mr. Cutler.*) At your pleasure, Sir.

31136. Unless you have any objection we propose to put your Memorandum, Mr. Cutler, as to the cause of and remedy for nuisance in Belfast Lough, on our Minutes ?—Certainly.

Knowing that nitrogen in some form or other is necessary to plant life, I have investigated the sources from which the waters of the Lough obtain their supplies of nitrogen, and have endeavoured to estimate the quantities entering the Lough from the various sources, as far as the analyses at my disposal enable me to do so.

The sources from which the nitrogen in the Lough appear to be derived are as follow :—

(*a*) The water entering the Lough from the land draining into it (including the River Lagan).
(*b*) Sewage from the City of Belfast.
(*c*) Sewage from the Harbour Estate and Shipping in the Lough.
(*d*) Sewage from the population (outside city) on the County Down shore.
(*e*) Sewage from the population (outside city) on the County Antrim shore.
(*f*) Sea-water entering the Lough at each tide.
(*g*) Animal life in the bed of the Lough.
(*h*) Animal and vegetable decomposition in the bed of the Lough.

The quantities of nitrogen attributable to the sources enumerated, except the last two (which I cannot estimate), together with the data from which they are derived are as follows :—

(a) *Water Entering the Lough from the Land Draining into it.*

The catchment area within the watershed (excluding 5¾ square miles, the built-upon portion of the city area) is 270 square miles, and the average annual rainfall may be taken as 36 inches. On the assumption that four-tenths of the total rainfall reaches the Lough, the average daily flow would be 154 million gallons. For the purpose of estimating the quantity of nitrogen from the catchment area I have had samples of Lagan water, above the city boundary, periodically collected and analysed by Dr. John Hawthorne, whose results are shown in Appendix No. 1 from which the average quantities of nitrogen are as follow :—

Nitrogen as free ammonia - -	·0116	parts per	100,000.
„ „ albuminoid ammonia	·0373	„	„
„ „ nitrates - - -	·0752	„	„
Total - - - -	·1241	„	„

Average daily quantity of nitrogen entering the Lough

$$= \frac{154{,}000{,}000 \times 10 \times \cdot 1241}{100{,}000} = 1{,}874 \text{ lbs.}$$

(b) *Sewage from the City of Belfast.*

Average daily dry-water flow at :—

Outfall works - - - -	= 15,500,000	gallons.
Sydenham outlets - - -	= 75,000	„
Total - - - -	= 15,575,000	„

Nitrogen in sewage (from Professor Letts' analyses) :—

As free ammonia - - -	2·553	parts per	100,000.
„ organic nitrogen - - -	2·232	„	„
Total nitrogen - -	4·785	„	„
Deduct 13·66 per cent. for sedimentation - - -	·650	„	„
Nitrogen entering Lough - -	4·135	„	„

Average daily quantity of nitrogen entering Lough

$$= \frac{15{,}575{,}000 \times 10 \times 4 \cdot 135}{100{,}000} = 6{,}440 \text{ lbs.}$$

(c) *Sewage from Harbour Estate and Shipping in Lough.*

Estate population (day only) - -	$= \frac{10{,}000}{2}$	= 5,000
Crews afloat - - - - - -		1,000
Passenger - - - - - -	$= \frac{9{,}314}{10}$	= 931
Cattle - - - - - - - -		= 654
Total - - - - - -		= 7,585

Total daily flow at 30 gallons per head
= 7,585 × 30 = 227,550.
Nitrogen assumed = 5 parts per 100,000.
Average daily quantity of nitrogen entering the Lough

$$= \frac{227{,}550 \times 10 \times 5}{100{,}000} = 114 \text{ lbs.}$$

(d) *Sewage from Population (outside City) on the County Down Shores.*

Population = 4,824.
Total daily flow at 30 gallons per head
= 4,824 × 30 = 144,720 gallons.
Nitrogen assumed = 5 parts per 100,000.
Average daily quantity of nitrogen entering Lough

$$= \frac{144{,}720 \times 10 \times 5}{100{,}000} = 72 \text{ lbs.}$$

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(e) *Sewage from Population (Outside City) on County Antrim Shore.*

Population = 10,000.
Total daily flow at 30 gallons per head
$= 10{,}000 \times 30 = 300{,}000$ gallons.
Nitrogen assumed = 5 parts per 100,000.
Average daily quantity of nitrogen entering Lough

$$\frac{300{,}000 \times 10 \times 5}{100{,}000} = 150 \text{ lbs.}$$

(f) *Sea-Water entering the Lough at Each Tide.*

Capacity of Belfast Lough between average low-water level and the bed of the Lough inside a line drawn northwards from Cultra at the end of the Victoria Channel = 13,000,000,000 gallons.

Capacity of Belfast Lough between average low and high-water inside same boundaries = 16,000,000,000 gallons.

Water entering above portion of Lough each tide = tidal capacity—(one-quarter daily flow from catchment area + Belfast and other sewage) = 16,000,000,000—42,500,000 = 15,957,500,000 gallons.

Nitrogen in sea water (Professor Letts' analyses):—
As free ammonia - - - = ·0010 parts per 100,000.
„ albuminoid ammonia - = ·0055 „ „
Total nitrogen - = ·0065 „ „

(This figure is rather low as nitrates are not included.)

Nitrogen entering above portion of Lough in sea-water at each tide

$$= \frac{15{,}957{,}500{,}000 \times 10 \times {\cdot}0065}{100{,}000} = 10{,}372 \text{ lbs.}$$

Average number of tides per day = 1·934.
Nitrogen passing into Lough daily
$= 10{,}372 \times 1{\cdot}934 =$ say, 20,000 lbs.

Estimated quantity of nitrogen entering Lough daily from above sources:—

(*a*)	Land drainage - - - - - -	1,874 lbs.
(*b*)	City sewage - - - - - -	6,440 „
(*c*)	Harbour sewage - - - - -	114 „
(*d*)	Sewage from County Down shore - -	72 „
(*e*)	Sewage from County Antrim shore -	150 „
(*f*)	Sea water - - - - - - -	20,000 „
	Total - - - - - - -	28,650 „
(*g*)	Animal life - - - - - -	Unknown
(*d*)	Animal and vegetable decomposition	„

Ulva Nurseries.

Although large quantities appear to be grown in Belfast Lough, the parts of the Lough where it grows attached in any quantity and where I presume it originates, appear to be very few. Generally, *ulva* will be found growing (in some places in very large quantities, in others in quantities which are scarcely appreciable) in the vicinity of streams of fresh water or sewers entering the Lough, and from a careful investigation of the foreshores it would appear that the extent of the growth is greatest in sheltered positions, and where the currents are slackest; and least, and sometimes non-existent, in exposed positions where the erosion of the shore indicates scour. It has also been noticed that nitrogenous mud and mussels are usually present where attached *ulva* is growing, and that the mud is richer in nitrogenous matter where the quantity of attached weed is greatest.

From the conditions existing it would appear that the nitrogen in the mud is obtained from decayed weed, sedimentary deposit from streams or sewers, excrement from mussel and other animal life on the foreshore, and from the decay of animal remains.

From a survey of the Lough it has been ascertained that mussels are growing in immense beds on the County Down shore between the Connswater and the Kinnegar at Holywood, and in smaller quantities at least as far as Cultra, also that extensive beds of mussels exist on the County Antrim shore between Mount Vernon and Greencastle, and smaller beds between Greencastle and Macedon. In addition to the mussels other forms of animal life, such as cockles and other bivalves which live beneath the surface, periwinkles and worms, abound on the foreshores of the Lough generally.

Of all the localities in the Lough where attached *ulva* is growing, the County Down foreshore, between the Connswater and the Kinnegar is not only the most fertile but the most extensive and appears to produce quantities of weed compared with which the weed grown in other localities is insignificant.

The peculiar conditions existing with regard to the area referred to are:—

(i.) That it is in the extreme upper reach of the Lough.

(ii.) That it is sheltered by the Holywood bank.

(iii.) That it is washed by the flow of the Lagan and Connswater, the flow of the Lagan being deflected by the west bank.

(iv.) That slack water by which it is covered at certain times of the tide encourage the deposit on it of the suspended matter brought down by the Lagan and Connswater.

(v.) That large quantities of living mussels (which attach the *ulva* by their byssus threads) abound on the site.

Besides the attached growing *ulva* in the Lough, there are in the summer time large quantities of loose *ulva*, which, I presume, have become detached from the nurseries by wave action and the wash from vessels, and there is no doubt that such loose *ulva* continues to grow prolifically until it is washed ashore, decays and causes the nuisance. No nuisance is caused by the *ulva* in its living state. It has been urged at various times by witnesses that the nuisance from the *ulva* in the Lough has greatly increased since 1893–5, when the main outfall works were put in operation, before which dates the sewage of Belfast discharged direct into the River Lagan, and I suggest the following reasons if such is the case:—

(i.) That, owing to the increased number, size and speed of the steam-vessels navigating the Lough, a greater quantity of *ulva* becomes detached and continues to grow rapidly until it is cast ashore and decays.

(ii.) That the mussel-beds, and consequently the *ulva* growing ground may have considerably increased, partly in consequence of fewer mussels now being gathered.

(iii.) That the periodical decay of weed has caused constantly increasing quantities of nitrogenous mud.

(iv.) That the population of the outskirts of Belfast (not contributing to the main drainage, but discharging its sewage on the shores of the Lough) has somewhat increased the supply of *ulva* growing food.

The nuisance in past years caused by the *ulva*, extended along the whole length of the County Down shore from Connswater to Cultra, and along the Antrim shore to a much less extent from the outfall works to Macedon Point, but since the formation of the Belfast, Holywood and Castlereagh Joint Board, the weed washed up on the County Down shore has been removed as it accumulated, and the nuisance considerably abated. In my opinion the nuisance would have altogether ceased if the Board had had sufficient money at their disposal to carry on their operations more rapidly and for a longer period each year. No cleaning operations have been carried out on the Antrim shore, except the removal of decayed weed and offensive mud from the angle formed by the embankments of the Northern Counties Railway and the outfall works reclamation, yet no complaints were made as to nuisance during 1909, and householders living on the shore of the Lough have informed me that no nuisance was caused. In connection with this it is significant that the sedimentation of the sewage at the Belfast Main Outfall Works has been continuously in operation since October, 1908.

Conclusions as to Cause of and Remedy for Nuisance.

1. That the initial growth of the *ulva* takes place mainly where there are nitrogenous mud deposits in the Lough.

2. That the *ulva* is principally anchored on such deposits by the byssus threads of mussels.

3. That it is nourished principally by the waters of the Rivers Lagan and Connswater and Sydenham sewage outlets.

4. That the nitrogenous matter in fresh water, apart from sewage is very favourable to its growth.

5. That the reduction of salinity by admixture of fresh water may in itself stimulate the growth of the weed.

6. That attached *ulva* cannot thrive in any quantity except in very slack waters, because where any appreciable current exists the light nitrogenous matter is not deposited, and spores would be swept away.

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7. That the sewage from the Belfast Main Outfall Works is not causing the growth of attached *ulva* on the County Down foreshore, although it may be assisting the growth of floating *ulva* which has become detached; because the sedimentation of the sewage has apparently effected a marked reduction of the *ulva* on the Antrim shore, but has made no difference to the Down shore.

From my conclusions as to the causes of the *ulva* growth, I am led to doubt whether any remedy for the nuisance will be effective except the complete scavenging of the shores as the weed is cast up, or the reclamation of the County Down foreshore where the attached weed principally grows; because, even with the removal of the whole of the nitrogen in the Belfast sewage the condition of the Lough water would still be favourable for the growth of the detached *ulva*.

Apart from the disposal of the weed, which is now under investigation, I am of opinion that an additional £1,000 per annum to the income of the Joint Board will be sufficient to effectively scavenge the County Down shore, and that the reclamation of the foreshore between the Connswater and the Kinnegar at Holywood, as shown on Appendix II., would cost £90,000.

For the information of the Commission I have given analyses and data relative to the Belfast sewage, and a chart of the Lough showing the location of the mussel beds (those on the Down shore being plotted from actual survey), also proposed line of reclamation.

APPENDIX No. I.

ANALYSES OF SAMPLES OF WATER TAKEN AT SHAW'S BRIDGE ABOVE CITY BOUNDARY.

Date.	Chlorine.	Nitrogen as Free Ammonia.	Nitrogen as Albuminoid Ammonia.	Nitrogen as Nitric Nitrogen.	Suspended Solids.
January 1st, 1909 - - - -	—	·0042	·0140	·1180	·5000
January 6th, 1909 - - - -	2·2	·0058	·0230	·0820	·3200
January 8th, 1909 - - - -	2·4	·0033	·0296	·0990	—
January 15th, 1909 - - - -	2·3	·0082	·0247	·1070	—
June 17th, 1909 - - - -	—	—	—	·0226	·0636
August 10th, 1909 - - - -	—	·0180	·0650	·0247	·1510
September 4th, 1909 - - - -	—	·0082	·0494	·0309	·0047
September 14th, 1909 - - -	—	·0132	·0576	·0309	·4050
September 28th, 1909 - - -	—	·0132	·0700	·0175	1·0840
October 12th, 1909 - - - -	—	·0107	·0453	·0620	2·2850
October 26th, 1909 - - - -	—	·0074	·0391	·0740	·9000
November 9th, 1909 - - - -	—	·0066	·0280	·0400	·6040
November 23rd, 1909 - - -	—	·0395	·0362	·0756	·1390
December 7th, 1909 - - - -	—	·0140	·0313	·1070	·4910
December 21st, 1909 - - - -	—	·0125	·0309	·1110	·5870
January 4th, 1910 - - - -	2·1	·0091	·0247	·1110	·5020
January 18th, 1910 - - - -	2·05	·0123	·0280	·1120	1·9420
Totals - - - - -	—	·1862	·5968	1·2252	9·9783
Averages - - - -	—	·0116	·0373	·0721	·6652
Averages, omitting June 17th, 1909 -	—	—	—	·0752	—

APPENDIX II.

ESTIMATE FOR RECLAIMING FORESHORES OF BELFAST LOUGH BETWEEN CONNSWATER AND KINNEGAR AT HOLYWOOD.

Reclamation No. 1 = 351 acres.

Yards.			£
1,666	Main bank - - - - -	at £13=	21,658
1,533	Cradge bank - - - - -	at £6	9,198
	Sluices - - - - - -		1,000
			31,856
	Add for contingencies - -		3,144
			£35,000

Say, £100 per acre.

Reclamation No. 2 = 197 acres.

Yards.			£
1,333	Main bank - - - - -	at £13	17,329
1,100	Cradge bank - - - - -	at £6	6,600
	Sluices - - - - - -		1,000
			24,929
	Add for contingencies - -		2,071
			£27,000

Say, £140 per acre.

Reclamation No. 3 = 197 acres.

Yards.			£
1,400	Main bank - - - - -	at £13	18,200
1,100	Cradge bank - - - - -	at £6	6,600
	Sluices - - - - - -		1,000
			25,800
	Add for contingencies - -		2,200
			£28,000

Say, £131 per acre.

	£
Total cost for 745 acres - -	90,000
Cost per acre - - - - -	121

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31137. Similarly, Dr. Adeney, we propose to put your Memorandum on the Minutes of our proceedings?—(*Dr. Adeney.*) I quite agree. I have for several years past been led to take an interest in the condition of the Belfast Lough by a long standing friendship, and from collaboration in the field of estuary pollution, with Professor Letts, to whose special investigations so much of the exact information, which at present exists concerning the condition of the Lough, is due.

Besides this, I have made careful inspections of the Lough for the Belfast Corporation in the year 1908, and again a few days ago, at low-water spring tide. I have been requested to give evidence before this Commission on behalf of the Belfast Corporation with regard to the two questions:—

(1) The causes of the nuisance which is experienced, at times, in the case of Belfast Lough; and

(2) By what means the nuisance may be avoided.

(1) *Cause of Nuisance.*

I am of the opinion that so far at least as the sewage, which is discharged from the Belfast outfall works by the wooden shoot is concerned, the nuisance is an indirect one, that is to say, it is not to be ascribed to putrefaction of the Belfast sewage matters, but to the putrefaction in the presence of sea-water of marine algae, the growth of which has been stimulated and promoted by the pollution of the waters and bed of the Lough with sewage matters. This statement may certainly be made without reservation as regards the south shores of the Lough.

As regards the northern shores of the Lough, it is necessary to remember that although the wooden shoot cannot be said to be closely situated to them, it is not so far removed from them as the southern shores, with the deep water channel between it and them. Up to quite recently, that is to say, before the Belfast sewage was subjected to a process of subsidence, and when the crude sewage was being discharged more or less close inshore, owing to the damaged condition of the wooden shoot, much of the sewage solid matters were deposited on the north side of the shoot. Owing to this state of things some nuisance directly caused by the sewage was no doubt

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experienced in the neighbourhood of the outfall works, and along the northern shore of the Lough; but even then it was, in my opinion, small compared with the nuisance arising from the *ulva* deposited on the foreshore of that side of the Lough. From the observations which I made at low water on the 8th instant in the neighbourhood of the shoot, I am of the opinion that the gross pollution of this part of the slobland by sewage solids is no longer occurring. This result is no doubt due to the fact that the Belfast sewage has been submitted to a process of subsidence before discharge since October, 1908, and it is fair to assume that nuisances directly arising from the gross pollution of this slobland by the Belfast sewage will altogether cease to be experienced in the future unless some unforeseen accident occurs.

As regards local discharges of crude sewage upon the foreshores on either side of the Lough, they no doubt directly contribute to the nuisance, especially in the immediate neighbourhoods of the discharging sewers, but there can be little doubt, that these local discharges contribute much more seriously to the indirect nuisance which has been so generally experienced up to quite recently at least by the inhabitants on both sides of the Lough.

(2) *Means by which the Nuisance may be avoided.*

This question is an extremely complicated one, and involves the consideration of a number of factors some of which are well understood, while but little is known concerning others; and it seems probable that some of the conditions affecting this question are at the present time quite unrecognised or at least have been until quite recently.

There can be no doubt that the growth of marine algæ, such as *ulva latissima*, is stimulated and promoted by the pollution of sea water by sewage or other waste organic matters; and it is most probable at the same time that admixture with fresh water is an important factor.

There can be little doubt also from Professor Letts' careful investigations, that ammonia, nitrites and nitrates, are amongst the most important, if not the most important, of the food materials which pollution by sewage can convey to sea water. But the important question is—can the *ulva* avail itself of such food supply in the absence of other materials or stimulating substances? So far as I am aware, no knowledge exists by which this question can be precisely answered—yea or nay. But judging from analogy with the more definite information that exists concerning other forms of vegetable life, the reply must certainly be in the negative.

Thus it is well known that ammonia and carbonic acid are amongst the essential food materials required by the organisms concerned in nitrification, but it is also known that it is impossible for these organisms to avail themselves of such food supply in the absence of certain organic and mineral substances. It is furthermore known that the organic substances present must exist in a particular form to exercise a stimulating influence on some of these nitrifying organisms. Such forms, for example, which occur in crude sewage, exert no such stimulating effect, but on the contrary inhibit the growth of the organisms referred to. Organic substances, such as occur in sewage, before they can exercise this stimulating effect, must undergo bacterial fermentation.

It has also been established that if two organic substances are capable, when existing together in solution, of stimulating and promoting the growth of water bacteria, the presence of either alone in solution may not be able to promote an active growth of the same organisms. These two questions will be found discussed and illustrated in the Report to this Commission on "The Pollution of Estuaries and Tidal Waters," Appendix 6 to the Fifth Report of the Commission, pp. 12–14, and 39–41.

It may fairly be stated that similar conditions have been found to obtain with higher forms of vegetable life, when these have been closely observed. Thus it is a matter of common observation that the growth of fresh water algæ is stimulated and promoted by the admixture of spring water and surface water containing organic substances of the form above described. Troubles arising from the luxuriant growth of fresh water algæ—the result of admixture of such waters for potable water supplies—are not uncommon.

It is hardly necessary to point out that all agricultural experience goes to show that organic matters for manurial purposes must undergo bacterial fermentation before they become available for plant life.

On turning to the question of the most favourable conditions for promoting the growth of *ulva*, the observations which I have made in other localities besides that of Belfast Lough appear to warrant the conclusion that the first required condition is pollution of a shallow sea water area by fresh-water-carried organic matters. Other and important conditions appear to be that the organic matters, either solid or liquid, shall not be present in sufficient quantity to produce a state of gross pollution, but in moderate quantity only, sufficient to set up a condition of active aerobic bacterial fermentation, the products of which or some of them, going to provide the stimulents, which together with ammonia, nitrates, etc., are required for the growth of the *ulva*.

A certain concentration of food materials also appears necessary for establishing at least an active growth of the weed.

There are obviously certain physical conditions necessary for the growth of the weed in the attached condition such as a favourable bed for attachment, and the absence of strong currents.

It is a matter of common observation as regards this weed, that very favourable conditions for its active growth are the discharge of sewage in relatively small proportions on to a flat foreshore or slobland that is not subjected to scour by tidal currents. A good illustration of such conditions as here referred to could be seen up to last year on the north side of the Liffey Estuary, along the Clontarf foreshore, where an *ulva* nuisance has been experienced during the summer season for many years past. The explanation of this appears obvious,—the deposited solids in the immediate neighbourhood of the outfall sewer undergo ærobic fermentation, and provide all the conditions as regards food supply in the concentrated condition necessary for the active growth of the weed; and when in this active state, the *ulva* is in a condition, whether attached or floating, of assimilating any food material in solution in waters flowing over it.

On applying the views above briefly outlined to the question of affording an explanation of the abundant growth of *ulva* in the Belfast Lough, and of suggesting the best means of preventing it, a first necessity seems to be the removal of all solid matters from the sewage which is being discharged into the Lough.

As regards the necessity for further treatment of the sewage for the purification of its soluble constituents, that in the opinion of the witness must depend upon the position of the individual outfalls discharging sewage. Speaking generally in reference to discharges on the foreshores of either side of the Lough, further treatment by filtration is necessary, varying perhaps in degree of efficiency with the position of the outfall and the special circumstances of the neighbouring localities.

With reference to the particular question of the necessity of subjecting that portion of Belfast sewage which is discharged into the Lough by means of the wooden shoot to any treatment supplemental to that of mechanical subsidence, I have come to the conclusion, after very carefully examining a few days ago the slob lands which are exposed at low water on either side of the deep water channel, that it is unnecessary.

I base this opinion on two considerations:—

> (1) The great improvement as regards gross pollution, which is noticeable in the condition of the slobland in the neighbourhood of the shoot since my previous inspection, and which must be regarded as the result of the process of mechanical subsidence to which the sewage has been subjected since October, 1908.
>
> (2) The present condition of the slob land which lies between the Connswater and the Kinnegar at Holywood, and which appears to be the chief nursery of the *ulva* in the Lough; and also that of the west bank; the condition of these together constitute a certain proof to my mind, that the former is not receiving solid matters from the wooden shoot; and that any dissolved matters which it may receive from it from time to time must be so largely diluted, in comparison with the food materials which it receives from other quarters, that they may be regarded as negligible.

The other quarters from which this slob land receives food materials, are the waters of the Lagan and of the

Connswater, which flow over it. I was informed by Mr. Cutler that a large quantity of the suspended matters which are brought down by the Lagan and Connswater, are deposited upon it in the slack water by which it is covered at certain times of the tide.

I have also learnt that chemical analyses of the waters of both these rivers have been made, and that the results shown that they carry with them considerable quantities of what may be regarded as food materials, both organic and inorganic; the organic constituents are no doubt in the form most favourable, for the reasons above explained, for stimulating the growth of the *ulva*, and more favourable for such purpose than the organic matters in crude sewage would be.

If the supply of the food material, which promotes the growth of the *ulva* on this slob land be drawn from the above suggested sources, it is obvious that no remedy would be effected by elaborately purifying the sewage which is being discharged from the wooden shoot. It therefore appears to me that the wisest and most desirable course to pursue in the interests of all concerned would be to adopt the suggestion which Mr. Cutler has made, viz., entirely to reclaim this stretch of slob land, and also that on the northern side of the Lough through which the wooden shoot passes, and which extends to Macedon Point. Mr. Cutler has informed me than the cost of carrying out the proposed reclamation would not be prohibitive; it would be less in fact that the cost of erecting filter beds for the treatment of the Belfast sewage.

The reclamation of these two large tracts of slob land would undoubtedly be followed by great benefits to the Lough and to those interested in it and in its neighbouring localities, besides destroying for all time the nursery grounds of the *ulva*, which has been the source of such serious nuisance for many years past.

31138. You have also prepared some notes of evidence, Mr. Hawthorne, which no doubt you will agree to our printing on our Minutes ?—(*Mr. Hawthorne*). Yes.

In 1898, under the guidance of Dr. Letts, I first began to study the question of *ulva latissima* in its relation to the nuisance which exists in Belfast Lough. The results of this work are summarised in the Report "On the Pollution of Estuaries and Tidal Waters," Appendix 6, to the Fifth Report of the Commissioners.

Recently, the work has been taken up again at the request of the City Surveyor.

Cause of Nuisance.

So far as the County Down side of the Lough is concerned, I believe this is due entirely to decaying *ulva*, and not, as has been sometimes alleged, to the deposition upon the shore of sewage solids from the Corporation's chute. I think the float experiments carried out by Mr. Cutler have shown pretty definitely that no considerable amount of sewage solids can cross the dredged channel.

I am not so well acquainted with the Antrim shore, but owing to the defective state of the chute some years ago, and to the fact that the sewage was discharged without sedimentation, it is quite possible that a direct nuisance due to actual sewage matter existed, in addition to the indirect *ulva* nuisance. Since the chute has been cleaned and since sedimentation of the sewage began, no nuisance has been complained of on the Antrim side.

Growth of Ulva.

The chief conditions for the growth of *ulva* seem to be :—

(1) A moderately rough surface into a cranny of which the spore can penetrate and there develop in quietness.

(2) Slack water when the frond develops.

(3) Suitable food.

(1). The first point is abundantly brought out on examining nurseries of young growing *ulva*. On the Holywood banks more particularly the young fronds are found growing in quantity on the shells of mussels (either dead or alive) and in nearly every case the little brown root is found at the extreme ragged edge of the shell, or where one of the shell layers ends.

A nursery of young *ulva* exists on the rocks at Macedon Point. This rock is rough and coarse and seems to be an argillaceous sandstone. A similar nursery exists at Cultra on sandstone rocks

(2). Slack water exists between Kinnegar point and the Connswater embankment, here are the chief nurseries of the young weed, which is rooted mainly to shells, I believe.

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Slack water exists along the reclamation bank between the chute and the County Antrim side. But *ulva* does not grow here, partly, I believe, on account of the softness of the mud and absence of stones and shells, although partly also because this portion is uncovered for too long a time between tides.

At Macedon Point the *ulva* nursery is protected from the direct wash of the tide.

At Greencastle there is very strong scouring action of the tide, as witnessed by the state of the railway embankment, and the full sweep of the Lough comes in here. Here, there is no *ulva* although the slob is comparatively hard and there are plenty of mussels. Seen from a distance this part is green; the greenness is due to sea grass, not to *ulva*.

A curious patch of *ulva* grows on a mussel bed just between the Greencastle Pumping-Station and the chute. This portion would appear to be somewhat higher than the rest and forms a sort of watershed when the tide is flowing or ebbing, where the water is comparatively still. This patch of slob is probably a prolongation of what is known as the Shell Bank which stretches from the chute about half way over the West Bank towards No. 10 Buoy. This Shell Bank forms a distinct watershed and the water races along both sides of it with the result that, although there is a considerable patch of mussels on the city side, there is no trace of *ulva*.

(3) *Ulva Latissima* is remarkable for its power of assimilating nitrogen in the form of free ammonia and nitrates. The Lagan brings down a considerable quantity of nitrogen in these forms, and it has been shown that a considerable quantity of its water flows over the slob on the southern shore where the *ulva* flourishes. In considering schemes for the removal of the nuisance, this factor must not be neglected.

Ulva does not appear to touch albuminoid ammonia, and albuminoid breaks down only very slowly into free ammonia, so far as regards mixtures of sewage and sea water at any rate. But the case of the albuminoid ammonia of the Lagan and other fresh water streams may be on a totally different plane. The Lagan is practically a canal through which there is a very sluggish current, and by the time its water reaches the slob land, fermentative changes of the organic matter may have taken place to such an extent that the final production of free ammonia or *ulva* food may be a very simple step indeed.

Shell Fish and Ulva.

Ulva frequently is found rooted to live shell fish as well as to empty shells, but far larger quantities of it are not rooted but are loose pieces, which have been tacked down by the mussels' byssus. These pieces grow to a very large size in slack water, being fed by the excretions of the shell fish in addition to what they extract from the water.

Dr. Letts has shown that mussels raise the amount of free ammonia in sea water very considerably, and I have found the same thing to happen in the case of other shell fish (such as cockles and the myacidæ), and of worms. In addition to liquid material, shell fish and worms produce some solid excreta of a rather glutinous nature which I have not examined, but which may account for the phenomenon often noticed, that a patch of mussels is raised above the remainder of the slob on a soft slimy mud. As I understand that mussels only live two years this mud may be a mixture of decomposed mussel and solid excreta which, by its stickiness, holds sand and other materials brought to it by the action of the waves, and which will slowly decompose into *ulva* food. This mud is very nitrogenous as the analysis of samples from the patch opposite Greencastle Pumping-Station shows :—

	Percentage loss on ignition.	Percentage of Nitrogen.
1. Mud from clean slob on City side of patch of *ulva* and mussels - -	5·51	0·144
2. Mud from middle of patch	9·33	0·271
3. Mud from clean slob on sea-side of patch - -	4·96	0 133

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In further illustration of the connection which seems to exist between *ulva* and shell fish, I should like to mention the case of Falmouth, where there are extensive oyster beds in Penryn River, and an *ulva* nuisance further down at the town. Teignmouth furnishes a better example, an *ulva* nuisance and mussel beds being in close proximity. (Letts and Adeney, Appendix 6, pp. 399, 409).

The connection between polluted fresh water, mussels and *ulva* can be very clearly traced by walking along the County Down slob from the Connswater towards the Kinnegar Point. At the mouth of the Connswater, which is a very foul stream, there is a large bed of large sized mussels. This patch is also covered with *ulva*. On passing Sydenham, the mussels become fewer in number and smaller in size. At the Tillysburn River they increase in number and in size and *ulva* is again abundant. Then they diminish together until the Kinnegar is reached, and there off the barracks outfall both are flourishing.

31139. Now, Mr. Cutler, you deal in your Memorandum with the sources from which the nitrogen in the Lough appear to be derived ?—Yes, Sir.

31140. I think it would be well for us to consider that first, because it opens the whole question of what the sources of pollution are, and how to remedy them. The land draining into the Lough (including the River Lagan) is mentioned as one of the sources ?—Yes, Sir.

31141. Does that amount to anything ; for example, Strangford Lough has streams of the same kind running into it, has it not ?—Yes ; the streams are considerably smaller than the streams going into the Belfast Lough.

31142. Smaller in Strangford Lough ?—Yes.

31143. Is it noticed that there is any appreciable quantity of sea lettuce in Strangford Lough ?—There is sea lettuce growing there I am informed, but I have not been there to inspect it. It is not to the same extent as at Belfast. The population near Strangford Lough is small ; Newtownards, I think, is the principal place draining into the Lough.

31144. Have you been down there, Dr. Adeney ?—(*Dr. Adeney.*) I have been down, but not for the purpose of examination ; just a casual visit.

31145. You do not happen to remember whether there is any special growth of *ulva* near the mouth of the rivers ?—No, I cannot say.

31146. Dr. Hawthorne, are you familiar with the condition of things there ?—(*Dr. Hawthorne.*) I do not know very much about that. I am afraid fresh water streams come in but very sparsely.

31147. It appears anyhow to be favourable to the growth of *ulva* ?—Where the water is salt.

31148. Is brackish water of any particular advantage to the *ulva* ?—I do not think so.

31149. Have you any remarks to make about the water entering the Lough from the land draining into it ?—(*Mr. Cutler.*) Well, Sir, I think it is a very important element. I have come to the conclusion that the brackish water is more suitable for growing *ulva* than the sea water. I am rather inclined to think that the nitrogen brought down by the river water is also better as a food for the *ulva* than the sewage is.

31150. On what do you base those statements ?—Well, the nitrogen in the sewage is largely derived from cooked food, and I do not think it is so easily assimilated or converted into the form suitable for the *ulva* growth as the nitrogen in the river would be.

31151. But we have, I think, had evidence, which I suppose is not to be disputed, that a considerable number of years ago, say twenty years ago, there was very little *ulva* in the Lough ?—Of course, I have heard the same thing, but I am rather inclined to doubt it. I think we get more fastidious as we get more conveniences in life and we get more civilised. We might say we indulge in more luxuries ; we take more interest in such things. I mean sanitary nuisances used not to affect people to the same extent as they do now.

31152. It is quite true we are getting more particular. Have any experiments been made—perhaps Dr. Hawthorne will tell us—as regards the actual growth of *ulva* in water, brackish water of the kind which would be produced by mixing Lough water with say, Lagan water ?—(*Dr Hawthorne.*) No, Sir, I have not any knowledge of this except at second hand, with the exception of some experiments that Dr. Letts and I carried out very early in this matter on the mixing of bacteria bed effluent with sea water.

31153. Yes, and did it grow successfully ?—It grew very successfully in the mixture.

31154. I see you give here under the heading (*a*), which is Natural Sources of Ammonia, you calculate the total rainfall as daily flow would be 154,000,000 gallons ?—(*Mr. Cutler.*) Yes, Sir.

31155. And then Dr. Hawthorne has analysed and given an average of the ammonia in this rainfall, and he finds there would be as much as 1,874 lbs. of nitrogen entering the Lough daily ?—Yes, that is arrived at by measuring the watershed of the Lagan, taking the average rainfall at 36 inches, then taking a usual engineering formula for getting at what flows off.

31156. Then you think that 1,874 lbs. a day would really be a very considerable source of supply of nitrogen for *ulva* ?—I do, Sir.

31157. It ought to be taken into consideration at all events ?—Of course, there is another element in that, that it flows over the biggest nursery in the Lough. The Lagan inclines towards the south of the Lough at the south side.

31158. Yes, I know ?—And the old Channel.

31159. We have got our map here ?—When I speak of the Lagan, of course I include the Connswater. The Connswater you will see comes round by the Victoria Park there.

31160. Yes, I know ?—Well, both the Lagan and the Connswater flow over those beds.

31161. Yes, at high tide they do, I suppose ?—I have a few float indications that I have had taken, they are marked on this chart ; it is the only copy I have. You will see the time of high water, and the times at which the floats were started, written in the corner.

31162. From this it appears that you put in floats between the islands ?—Yes, Sir.

31163. And many of those floats have been carried over ?—They were put in every half hour during the ebb tide. You will see them numbered, 1, 2, 3, 4, etc.

31164. Four of those floats which have been put in during the ebb tide have been carried on to the Tillysburn area, near the Holywood bank. These others have apparently been carried out, and have not crossed the Victoria Channel ?—No, Sir.

31165. That runs parallel to the chute ; the other six have run pretty nearly parallel to the chute, but have not gone very far. Shall I pass this round ?—Yes.

31166. Well, what do you regard that as showing ?—I think the Lagan water inclines towards that side, and you get a larger admixture of the Lagan water with the sea water over those beds than you would anywhere else on the Lough.

31167. I presume on the North side of the Lough there is not nearly so much *ulva* ?—No, Sir.

31168. It does not constitute a serious nuisance there ?—No, Sir ; not at present at any rate.

31169. Then you think that the partial fertilisation of the *ulva* at all events is due to nitrogenous matter carried down to the Lagan ?—I think the whole of the nursery, as one may call it, between the Victoria Park, between the Connswater and the Kinnegar, is fertilised by the waters of the Lagan, the Connswater and the discharges of sewage on that shore.

31170. Yes, we will come to the sewage later.

31171. (*Sir William Power*). Have you estimated the amount of nitrogen brought down by the Connswater daily ?—I have not separated it ; I included that in the watershed, so as to separate the city sewage or the nitrogen from the city itself. I took out the watershed and deducted the area of the city, 5¾ millions, and I had the samples of water taken in the Lagan above the city boundary, so as to get the nitrogen coming down before it reached the city, and I have based the nitrogen on the whole of the watershed on those figures.

31172. (*Chairman.*) I notice Dr. Hawthorne says *ulva* does not appear to touch albuminoid ammonia. "And albuminoid breaks down only very slowly into free ammonia, so far as regards mixtures of sewage and sea water at any rate. But the case of the albuminoid ammonia of the Lagan and other fresh water streams may be on a totally different plane. The Lagan is practically a canal through which there is a very sluggish current, and by the time its water reaches the slob land fermentative changes of the organic matter may have taken place to such an extent that the final production of free ammonia or *ulva* food may be a very simple step indeed." The albuminoid ammonia in Mr. Cutler's statement amounts to about more than a quarter of the total. Of course, if it is not available it diminishes the total supply of nitrogen considerably. Would you agree ?—(*Dr. Hawthorne.*) That was the reason for putting that in the albuminoid ammonia in the total, as a source of ammonia.

31173. Have experiments been made on the actual growth of the *ulva* in water freed from ammonia, but containing albuminoid ? It could easily be got by boiling off the ammonia. Do you know whether any experiments have been made to show whether albuminoid ammonia will nourish *ulva* or anything similar ?—In our preliminary experiments with *ulva* we found that the free ammonia disappeared very rapidly, but that the nitrogenous organic matter revealed by the albuminoid ammonia test did not seem to be touched at all, even after several weeks.

31174. But you think that ultimately the albuminoid ammonia will turn to free ammonia probably by fermentation ?—Yes, Sir, if it remains in the Lough. (*Mr. Cutler*) There is that other point about ammonia. I think in the river water it breaks down very much more readily than it would in general sewage. I think Dr. Hawthorne would verify that.

31175. What proof can you give for that ?—(*Dr. Adeney.*) I will take that up afterwards, or shall I take it up now ?

31176. I think so. Perhaps if you could you will throw light on each subject when we are discussing it. I think that would be more convenient ?—Well, the whole question with regard to the influence of organic matter in the growth of this weed is an extremely important one. It is a very difficult one, of course. It has not been, so far as I know, investigated, and the only suggestion I can make is to reason from analogy with vegetable growths the physiological chemistry of which we do know something about ; I refer to fresh water algæ. We know that spring waters for instance unmixed with surface waters do not contain favourable food material for the growth of fresh water algæ, but if surface and spring waters become mixed together, you then have a water which possesses food material extremely favourable for the promotion of the growth of fresh water algæ, and it is owing to mixtures of waters of this kind that troubles in connection with potable water supplies have arisen, and I am aware of one myself in Dublin. It is held by authorities on lake and pond waters that a number of factors must exist in the water to ensure the growth of fresh water algæ, and amongst these is organic matter, but that organic matter is not crude organic matter, such as we find in sewage, but matter that has undergone bacterial modification. It is comparable in chemical and physical properties to the humus in garden soil. Perhaps I may quote one of the leading American authorities on the subject from a book I have here, "The Microscopy of Drinking Water," by George Chandler Whipple. In a preliminary consideration of what he calls ground water and surface water he makes this statement : "Ground water collected directly from the soil, before it has had an opportunity to stand in pipes or to be exposed to the light, is almost invariably free from microscopic organisms ; its passage through the soil filters them out. It usually contains an abundant supply of plant food extracted from the organic and mineral matter of the soil and modified by bacterial action, and when the water reaches the light this food material is seized by micro-organisms." If you take extremely simple forms of vegetable growth, for instance the organisms concerned in nitrification, some experimental results are on record and they show the very intimate influence which the presence of organic matter exerts upon the life history of these organisms. For instance, as you no doubt are aware, Sir, ammonia is nitrified to nitric acid by the operation of two organisms ; one organism converts the ammonia to nitrous acid, and the other organism converts the nitrous acid to nitric acid. For many years certain experiments of Warington, on nitrification had no explanation. He experimented with water extracts of humus from garden soil, mixed with ammonia chloride, and easily obtained the complete nitrification of the ammonia to nitric acid ; but he found that, on taking very dilute solutions of this humus mixed with ammonia chloride, he came to a point when the fermentation did not proceed beyond nitrous acid. He could easily get the fermentation to nitrous acid, but not beyond. Now, in the Appendix 6 to the Fifth Report of the Commission, there is an experiment recorded which bears directly upon this very question ; it is on pp, 39-40, and the first experiment I would refer to is on p. 39. It is simply a solution in distilled water of ammonium chloride and small quantities of potassium phosphate and sodium carbonate—but no added organic matter—seeded with a few drops of the mixed sediments from the solution of peat which had previously been employed for experiments on nitrification, and this solution was corked up in bottles and completely filled, and kept out of contact with air. The bottles were kept for a considerable time, and when their contents were examined it was found that the whole of the dissolved oxygen had been absorbed. Some ammonia had also disappeared, and its place was taken by nitrous acid. The next experiment marked 2, illustrates the influence of the presence of organic matter in suitable form on nitrification. The solution of humus employed had been experimented with previously, and it was from the sediment in those solutions that the first experiment was seeded. One thousand cubic centimetres of this peaty solution were diluted with 2,000 cubic centimetres of distilled water, containing a known quantity of ammonium chloride. The result shows quite a different result. As before, all the dissolved oxygen is absorbed ; a larger quantity of free ammonia is absorbed, carbonic acid also is taken up, but that ammonia is converted apparently wholly into nitric acid. Now, there was only one factor not common to those two solutions The organisms were the same ; and they both contained ammonium chloride and mineral salts, and the only difference was the presence in the second solution of organic matter as humus. On referring to the column headed "CO_2," you will find there was a fixation of carbonic acid in both experiments, showing that although the organic matter appears to have exercised this fundamental influence on the course of nitrification it did not give up any of its carbon to the formation of carbonic acid. Of course, it probably did so to form tissue. That is one point. Again, it is a matter of general agricultural experience that organic matter for manurial purposes must undergo bacterial change in the soil before it is available for plant life. My point is this, that so far as I know all vegetable growths, higher in the scale of life than bacteria, and dependent on external sources for food supplies, except the nitrification ferments, as I have indicated, require organic matter in the fermented condition as a stimulant in the processes of tissue formation. That, it seems to me has an important bearing in approaching the question, of what is the cause of this luxuriant growth of weed wherever it occurs, and what is the remedy. If the ulva require fermented organic matter as a stimulant in its constructive metabolic processes, then that which grows on the slobland that lies between the Connswater and the Kinnegar in all probability derives its supply of such matter largely, if not wholly, from the waters of the Lagan and Connswater, which, as Mr. Cutler and Dr. Hawthorne have pointed out, bring down considerable quantities of organic matter on to this portion of the Lough ; and these organic matters are no doubt largely of a fermented character. Do I make myself clear ?

31177. You make yourself perfectly clear, and I should like to ask whether any experiments have been made similar to those that you have made with peat, supplying a similar amount of organic matter ?—I do not think so ; clearly they should be made. I do not think there can be any question, if there is any strength in arguing from analogy, that there are other causes than the supply of free ammonia and nitrites and nitrates for the vigorous growth of *ulva*. This *ulva* seems to be an extremely interesting growth. If you look at the experiments described by Professor Letts in his article in this same

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Appendix, on p. 157, Professor Letts gives some extremely interesting experiments on the subject of this absorption of ammonia by *ulva* in daylight and in darkness. Now, previously he has shown that in daylight a large absorption of ammonia, and a considerable evolution of oxygen occurs. In darkness, as in the case of other vegetable growths, the formation of carbonic acid and an absorption of oxygen, may be observed. But in darkness a very considerable absorption of ammonia may occur as well as in the daylight. That it seems to me is an important, a very important, factor, to have brought out, because this weed can at all times, day and night, as it were store up at any rate one of the food materials which it requires, and possibly in sunlight or daylight, with other necessary conditions obtaining, utilise it for the building up of tissues. It is not conceivable, unless there is some other process at work for energetic purposes than daylight, that in the dark the *ulva* would convert ammonia into tissue, although it can absorb it in the darkness.

31178. The darkness would be no assistance practically? —Exactly.

31179. As regards those fresh water plants, of course they draw their nutriment entirely from the water; they are not rooted and they do not absorb from roots?—Yes.

31180. The CO_2 which they assimilate must be entirely in solution?—Yes.

31181. And possibly the ammonia and possibly also the nitrous and nitric acids, are entirely in solution?—Yes, but the point is, of course, the intervention of some stimulating agent between those two and carbonic acid.

31182. You want ammonia, the combined nitrogen and combined carbon?—And you want organic matter.

31183. Then to sum up this part of the inquiry, no inconsiderable quantity of the nitrogen which furnished nutriment for the *ulva* may be taken as derived from the Lagan and other tributaries and the rainfall generally?—I think it is quite possible, at any rate I do not think we ought to conclude that it is not until after we have a direct proof to the contrary; it is such an important point.

31184. I would just direct the attention of the Commissioners to Mr. Cutler's Memorandum. You think, Mr. Cutler, that something in the nature of 2,000 lbs. of nitrogen would enter the Lough as land drainage daily?—(*Mr. Cutler.*) Yes. Except that I think Dr. Hawthorne will tell you that is not the total nitrogen. I think that is the sum of the albuminoid, the free and the nitrate; there may be something beyond that.

31185. Something that you cannot detect, therefore for our purpose it is not there?—(*Dr. Hawthorne.*) When I conducted these experiments on the Lagan we were interested only in the ammonia and the nitrates. Really the object was to determine those two just in order to get a rough idea of the nitrogen which was present. I also made an albuminoid ammonia test with permanganate. Of course, that albuminoid ammonia test does not reveal all the organic nitrogen.

31186. No, but would you not agree that the nitrogen that it does not show would have practically no action; you would not agree that?—I do not know that that follows, Sir. (*Dr. Adeney.*) Albumen would only yield a comparatively small fraction of its nitrogen to the albuminoid ammonia test.

31187. When it is attacked bacterially it would give its nitrogen up, you think? To a greater extent?—(*Dr. Hawthorne.*) If I had determined the nitrogen by the *Kjeldahl* method it would be a more satisfactory statement.

31188. You did not use the *Kjeldahl* method for that? —No, only the albuminoid test.

31189. Then, Mr. Cutler, shall we pass on to the sewage? —(*Dr. Hawthorne.*) I made a number of analyses of the Connswater and amongst others of a sample which was taken in the Connswater River at a place where a large distillery was discharging a hot, strong-smelling liquid under the surface of the river. This is not in my summary, Sir. I could not get the liquid at the exit; it was already mixed with the water of the river. There was about 1½ feet of water in the river. The free ammonia in the sample, as I received it, was ·16; the albuminoid was 2·96, but the total organic nitrogen was 5·19

31190. And the difference would be what?—2·23.

31191. Then it comes to this; that you think this is a minimum estimate, this 1,874 lbs. which leaves out of account a quantity of nitrogen which has not been estimated yet, but which could be got at by *Kjeldahl's* method?—Yes, Sir, at the same time I do not think the difference is so great as in the case of sewage. I made one determination as a check on the Lagan water, and the figure given by the *Kjeldahl* there was very slightly greater than that given by the albuminoid ammonia test. (*Dr. Adeney.*) May I remark that as far as the albuminoid ammonia test is concerned it does not indicate anything like the total nitrogen in a crude sewage, but in a good sprinkler effluent the determinations by albuminoid ammonia and *Kjeldahl* closely approximate.

31192. Showing that the more refractory matters have been broken down?—Yes.

31193. To pass on to the City of Belfast Sewage; you calculate the total amount of nitrogen entering from the sewage by taking into consideration the average dry weather flow?—(*Mr. Cutler.*) Yes, Sir.

31194. The total being 15½ million gallons practically? —Yes, Sir.

31195. Then from Professor Letts' analyses you calculate the nitrogen in this sewage as free ammonia and as organic nitrogen, and you assume that a certain amount of sedimentation need not be counted?—Yes, Sir, that is the result of twelve months analyses. The total nitrogen, the 4·785, is the nitrogen determined on one of the dryest weeks of the year because I have taken the dry weather flow, but taking the average flow treated during the year and the average nitrogen figure, they are almost exactly the same. With regard to purification that 13·66 indicates the percentage purification throughout the year so I have deducted that from those figures to show what we are putting in now.

31196. I see, and you find the nitrogen entering the Lough is about 4 odd parts per 100,000 of the water?—Yes, Sir.

31197. And by summing up, knowing the dry weather flow you get 6,440 lbs.?—Yes.

31198. Then your contention would be that this, though a large figure, still bears a considerable proportion to the amount of nitrogen entering the Lough otherwise? —It does.

31199. You next take the sewage from the harbour estates of the Lough?—Yes.

31200. Is it necessary to spend time over that; they are very small quantities?—No; I wanted to account, as far as I could, for the whole of the nitrogen.

31201. One hundred and fourteen lbs. from the harbour sewage, 72 lbs. from the population on the County Down shore, and 150 lbs. from the population on the County Antrim shore?—Yes.

31202. Then you make another calculation under head (*f*) which strikes me as more risky?—I put it up to give the Commission the figures. I do not say that all that nitrogen is assimilated by weed or is ready to be assimilated by weed.

31203. But you think it is carried into the Lough at each tide?—Well, not exactly, because of course the Lough water goes out and it gets diluted with the sea water outside and it comes back partly diluted. It will contain more nitrogen when it comes back, I think, than pure sea water would.

31204. We have the prospect of making experiments as to the growth of *ulva* in what one may call perfectly pure sea water, off some lighthouse where there is no chance of contamination of any kind. Until these are made I do not think you could argue upon this combined nitrogen and seawater?—I do not want to put any argument with regard to it, but it seemed to be an important figure, and I gave it for what it was worth.

31205. It is a very astonishing figure that 10,372 lbs. is brought in daily by the tides?—The way I look at is this; supposing there is no pollution of any kind in the Lough that would be the figure that would be brought into the Lough and taken out every tide.

31206. It is a fair statement, but I do not think you could draw many conclusions from it. Under headings (*e*) and (*h*), you assume it is impossible to make an estimate of the nitrogen yielded by the animal life in the Lough or the animal and vegetable decomposition in the Lough ?—Yes, but I think they are very large quantities.

31207. I agree they might be large quantities. Now as regards the position of the *ulva* ; the *ulva* nurseries ?—Well, by far the largest quantity of *ulva* is growing—when I say growing I mean attached in some form or another—between the Connswater and Kinnegar.

31208. The Kinnegar Point ?—The Kinnegar Point, yes, by far the larger quantity. And there is *ulva* growing rooted. I wish to make a distinction as to the ways in which the *ulva* is attached. As you will see, Sir, from the plan I think I gave you, there are large beds of mussels on that shore. The black marks there indicate the mussels in the densest deposits, and round the dense deposits there are hatched portions which are less dense and so on. The total area of mussel beds between the Kinnegar and the Connswater amounts to about 300 acres.

31209. Have those mussels been there from time immemorial ?—It appears to me so. For another purpose I was sinking a trial hole at the end of the Twins here and went down 40 feet right on to the red clay and I found shells and decomposing animal matter all the way down, even right to the bottom. I had a sample collected of the water that was coming into the hole on the top of the red clay. That was highly polluted with organic matter.

31210. (*Sir William Power.*) Where was that ?—At the end of the Twins, between the Musgrave Channel and the Victoria Channel, and if the mud is turned over here it appears to be full of shells.

31211. Full of shells ?—Yes.

31212. They have been growing there for a very long time ?—Yes ; I think that is clear from the fact that there have been enormous exports of mussels to Scotland for fishing purposes from Belfast. You will see that in every book you read, that the mussels are exported from Belfast Lough for fishing purposes.

31213. Are they still used ?—Yes, but not to the same extent.

31214. If the trade has been larger in former years than now is it not possible that the continual export of mussels, the continual taking of them off the shore by the population who wanted to sell them, would not clear the shore, not merely of mussels, but of the *ulva* attached to them ?—If they were gathered in sufficient quantities.

31215. If they were gathered in sufficient quantities ; was that done ?—Oh, I do not think so. I think the mussel beds, since the collection diminished, would have increased to much greater dimensions than they were formerly.

31216. You mean you think the present mussel beds are much larger than they used to be ?—I should think so.

31217. Owing to their non-collection ?—I cannot speak from actual knowledge, but I should think so. (*Councillor McCullagh.*) With reference to the shipment of them, I got returns made by the Harbour Authorities which give it accurately since 1884. That has, of course, to do with the shipment of them ; it does not deal with what has been gathered for private purposes and sold.

31218. (*Colonel Harding.*) That would be relatively small ?—I would not say that, because for a number of years there was a considerable trade carried on ; every shop used them themselves extensively and whenever that notice was put up by the Public Health Department, warning the people against gathering them, they dropped off practically altogether.

31219. (*Chairman.*) The export is almost stopped at present ?—(*Mr. Cutler.*) Yes, Sir. You see a note at the bottom of that chart, when the first notice was served.

31220. That is to say when they were prohibited, but that would not hinder their export for bait, would it ?—I think the price governs the export of mussels for bait ; the price that can be obtained.

31221. In 1894 there was an enormous export ?—Yes, enormous, and it gradually came down till it is practically nothing now.

31222. In 1894, was the *ulva* obnoxious on the shore ?—I think we are told it has been considerably on the increase since our sewage was turned into the new outfall, and that was between 1893 and 1895.

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31223. (*Colonel Harding.*) It is rather the other way, that immediately on the change there was an improvement from 1893 to 1895 in the Tillysburn area, but it was suggested that owing to the defects of the chute at a later period the evil returned to Tillysburn ?—I am mistaken. I thought it was alleged that since the commencement of the discharge of sewage at the main drainage outfall, the present one——

31224. But nothing was heard of *ulva* as a nuisance in 1894 ?—(*Dr. Hawthorne.*) Oh yes ; I was living at Holywood at that time and it was very bad indeed in those years. I lived there from 1892 to 1896, and it was very bad indeed at that time.

31225. In spite of the mussels being gathered in large quantities ?—Yes, Sir. (*Mr. Cutler.*) I wanted to say, Sir, that this *ulva* is attached in various ways on this bed. Between the Connswater and the Kinnegar you find large quantities attached by the byssus of the mussel, by far the largest quantities. You also find *ulva* growing to shells, and on the other side of the Lough, on the Antrim side, I have observed very small quantities of *ulva* which appeared to have been washed up on to the bank which is covered by succeeding tides by mud, partly covered and this enabled the weed to keep on growing, and there are blocks of mud, I suppose about as big as that, (*Indicating*) standing 4 or 5 inches above the shore level, with a very luxuriant growth of *ulva* on the top. If you separate those blocks of mud you see the *ulva* perfectly black where is it imbedded, and I take it the upper part of the *ulva* is getting its nutriment from the mud it is imbedded in.

31226. You think it grows like an ordinary land plant ?—In that case it was. I was examining it last week ; I was examining the shores. The first time I saw it it was not important, but it was growing in that way, and I made a note of it. (*Dr. Adeney.*) There is another explanation, Sir.

31227. What is it ?—It is growing not through any root attachments in the mud, but from the fermentation of the polluting matters in the mud, the products of the fermentation being dissolved and being carried up, and absorbed by the portions of the *ulva* directly exposed to the water.

31228. Would it even require that as long as it is anchored in one place and a good deal of it is free in the water. I thought it would get its nutriment in the ordinary way, and the part in the mud would simply serve as an anchor ?—I think so. I am not aware that it has even been suggested that the *ulva* obtained its food except from matters dissolved in water.

31229. No, I think not ?—(*Mr. Cutler.*) Of course this *ulva* would not have gone on growing in the position in which I found it had it not been for the mud, because had it not had the moisture, during the period of low tide, it would have decayed. I have also found *ulva* along the shores past that area I have just described, but strange to say it is not growing attached to the mussels there, but growing on the surface of rock. Principally on the surface of rock. Round Cultra there was plenty of *ulva* growing in very small pieces attached to the rock and there were plenty of mussels about, but there was no *ulva* attached to the mussels. On the Antrim side, where you see that large bed of mussels shown on this plan, the mussels are perfectly free of *ulva* except in one portion, a small band, I think it was about 300 feet wide, in the middle of it. It is quite insignificant in amount but it was attached to the mussels there. There seemed a sharp line of demarcation between where the *ulva* was growing and where it was not growing on both sides, and as I walked over the ground I noticed a change in the character of the mud. I had samples collected where the *ulva* was growing and one about 300 yards on either side of it, and I sent those to Dr. Hawthorne to analyse. He will give you the results of those analyses. It seems to me at the present time, at any rate, the only place where the *ulva* is attached to the mussel by byssus thread is on that portion between the Connswater and the Kinnegar Embankment.

31230. I think Dr. Letts suggested some sort of symbiosis of the *ulva* and the mussel, that the *ulva* gets its nutriment partly from the excreta of the mussel, and the mussel I presume eats the small creatures which are attracted by the *ulva* ; the mussel is a feeder on animals ?—

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I think it consumes both microscopic plants and animals. You will observe that that portion of the shore is the most protected I think of any.

31231. You mean the Tillysburn area and thereabouts ?—Yes. You will see there is a bend in the Lough there, and the Holywood Bank practically goes out to the channel at low water, and it protects that area from commotion of the water. It is up at the end of the Lough, which would argue that it should be a slack water there, and there is practically no erosion on the shore itself, and I think that its slack water there is one of the conditions most favourable to the growth of *ulva*.

31232. (*Sir William Power.*) Is the slob land growing there ? Is it higher than it was years ago ?—Well, I am not sure, Sir. I think on the other side Mr. Kelly, the Harbour Engineer, reported that it had been rising. He probably will be able to give you more information with regard to that than I can.

31233. But the conditions you mention would favour growing up of the slob ?—I do not think there is any doubt that it is growing, but it is growing I think partly by the decay of the shell fish, and the decay of the weed, because the mud is getting very thick there, very thick indeed, and the place where the mud is thickest is nearest to the Connswater, and as you walk along the shore of the Tillysburn the mud seems to get less and less. That is to say, it is far more dangerous to walk close to the Connswater than it is further along the shore, and where there is the most mud the mussels seem to be larger and denser, and the growth of weeds seems to me to be greater. If you look at that map, Sir, where the mussels are, you will notice that wherever there is a stream of fresh water, whether it is foul or otherwise, the mussels seem to be most prolific. The Tillysburn stream which is indicated there has a fairly good flow of water, and I do not think there is much pollution in it, but the mussels seem to grow very thick just by that stream. You will also notice that in the Connswater the mussels are very thick. We know that is highly polluted. Then at Holywood opposite the Kinnegar, the outfall from the Kinnegar comes in where you see this bed of mussels. At Holywood opposite the Point there are numerous outfalls. There the mussels are growing as much as the erosive effect of the tide will allow them to do. At Cultra there is an outfall, and the mussels are growing pretty freely there, especially at the mouth of the sewer ; on the other side of the Lough at Green Castle, at Whitehouse, and also near Macedon Point, and wherever there is a stream of fresh water coming out, whether it is polluted or not, there appears to be a growth of mussels. The mussel beds on the County Down shore are actually surveyed. Those on the County Antrim shore I have only been able to sketch on.

31234. So that you think that the mussels and the *ulva* keep together very largely, the mussel serving as an attachment for the *ulva* ?—Yes.

31235. Are the mussels ever covered over with the mud, or do they usually lie on the top ?—They lie on the top. The cockles are beneath the surface, and what we locally call the cockabilias live below the surface ; the mycidæ.

31236. You suggest that the nitrogen in the mud is obtained from the decayed weed, a sedimentary deposit from streams or sewers, excrement from mussel and other animal life, on the foreshore, and from the decay of animal remains ?—Yes, Sir. There is decayed weed there in large quantities. Anybody can see it, because if you just take hold of the mud and wash it, you will see the remains of weed in it.

31237. Now, you raise the point in your memorandum that the steam vessels navigating the Lough will detach *ulva* which will continue to grow rapidly until it is washed ashore and decayed. Is there such a very large increase in the number of vessels that come up the Lough ?—Yes, a considerable increase. There are more steamboat routes open now, and in the summer there are two trips in connection with most of the routes.

31238. But I suppose you mean it is merely the wash of those ships that break through the slob lands, and detaches the *ulva* ?—Particularly at near low water you see an enormous wash from the vessels raking that shore, just where the *ulva* is growing on those mussels, that is when the banks are washed. I do not suggest that when the tide is high, but just when the banks are washed. That is the time I think when the *ulva* gets broken off.

31239. Then you mention that the mussel beds have considerably increased. That is what we have been talking about before ?—Yes.

31240. That the periodical decay of weed has caused constantly increasing quantities of nitrogenous mud. As regards the increase of population, the fourth heading, I thought on the whole that could not be maintained. I thought for instance the population of Holywood had hardly increased at all for the last century ?—I was referring to the city.

31241. I beg pardon ; the city of Belfast ?—Yes ; I mean that portion of the city which was taken in at the time the Borough boundaries were extended, which did not, and do not now, mainly contribute to the main outfall works.

31242. That is the population that drains ?—At Lower Sydenham we have a sewer going out on to the shore near the Sydenham Station, and we have other sewers draining through into the Connswater there, close to Victoria Park.

31243. The sewage of which does not reach the main outlet at all ?—Yes, Sir.

31244. Further you suggest that the nuisance would have altogether ceased if the Belfast, Holywood and Castlereagh Joint Board had had sufficient money at their disposal to carry on their operations more rapidly and for a longer period each year ?—Yes.

31245. That is in collecting *ulva* and disposing of it ?—Yes, Sir.

31246. Do they get any price for it ?—No, they have to pay the farmers to take it away at present.

31247. Are the farmers willing to take it away ?—Well, they are willing enough to take it when they can. At some periods of the year the horses are being used on the farm, and they do not care about taking it then.

31248. But they think it is a fairly good manure ; they are willing to take it from a manurial point of view ?—I think there is no doubt about that. I think if we could get it well into Belfast, we could get rid of a lot of it with these nurseries and people of that kind.

31249. (*Sir William Power.*) Have the cleansing operations for the Tillysburn area extended to low water mark ?—No.

31250. Or have they been mainly near to high tide mark ?—Near to high tide mark where it gets washed ashore. You see, if you extended the operations over the whole of the slob bank there, it would be a very costly operation. It is so difficult to get about on that mud. One sinks in to such a depth, falling in walking over it ; and then where it is lying on the mud I do not think there is any trouble with it. It does not decay so readily as when it gets washed ashore, although I think they should go further afield than they have done.

31251. (*Chairman.*) Further out on the banks ?—Yes, Sir.

31252. This puzzled me somewhat as regards the statement : "No cleaning operations have been carried out on the Antrim shore, except the removal of decayed weed and offensive mud from the angle formed by the embankments of the Northern Counties Railway and the outfall works reclamation, yet no complaints were made as to nuisance during 1909, and householders living on the shore of the Lough have informed me that no nuisance was caused." That refers to the Antrim shore, I suppose ?—Yes, Sir. There is one gentleman, Mr. McLaughlin, who lives in a house at Macedon Point. He volunteered information to me that there had been a marvellous improvement during 1909 ; in fact, that they had not had any nuisance at all.

31253. (*Mr. Tatton.*) How do you account for that ?—Well, it is rather early to speak, but it is a notable fact that this is the first year that we have had no complaints from that shore, and it is the first year we have been sedimenting our sewage. One does not like to speak too definitely about a thing of that kind, although it all points that way.

31254. But still there is a vast amount of mud on that shore ?—Oh, yes, there is plenty of mud.

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31255. Do you think the mud would be the cause of the nuisance; was it the mud that caused the nuisance before ?—The cause of the *ulva*, Sir, you mean ?

31256. Was it the mud or the *ulva*, or both ?—There was a direct nuisance on that shore from sewage solids, as well as an *ulva* nuisance, because there is no doubt about it that the bulk of the solids from our sewage was deposited on that slob between the chute and that shore. (*Dr. Adeney.*) In 1908 I may mention that I passed along there and examined that slob land. It was then in a grossly polluted condition.

31257. (*Chairman.*) To sum up the case: as a remedy for the nuisance you think that no remedy would be effective except the complete scavenging of the shores as the weed is cast up; and also the reclamation of the County Down foreshore where the attached weed principally grows ?—(*Mr. Cutler.*) Yes, Sir.

31258. Even after the removal of the whole of the nitrogen in the Belfast sewage, you believe that the condition of the Lough would still be favourable for the growth of the detached *ulva* ? Apart from the disposal of the weed (and this is now under investigation), you are of opinion that an additional £1,000 per annum to the income of the Joint Board will be sufficient effectively to scavenge the County Down shore; and that the reclamation of the foreshore between the Connswater and the Kinnegar at Holywood would cost £90,000. That is a very interesting statement, the possible cost of the reclamation.

31259. (*Colonel Harding*). That is the cost of a bank simply to enclose the area ?—That is the cost of a bank. I think I gave in evidence before yourself, Colonel Harding, something with regard to the reclamation remedy. I think you put the question to me; I have not gone into the figures. I think I gave you a price somewhere about half the cost per acre that I give here. That is accounted for in this way. I think for reclamation to be effective it should be done at once. If it is to be done at all, it should not be delayed for eight or ten years. It could quite easily be done in a couple of years, and if it to be done at all, it should be done in the shortest time possible.

31260. Do I understand that the reclamation from Musgrave Channel to the Kinnegar could be carried out in two years ?—Yes, Sir; to do it that would be necessary to get material to make the bank. In contemplating the reclamation of that shore on previous occasions, I have always taken into consideration that we could use largely the material scavenged from the town, which, of course, we would get for nothing, but that would mean that it would take a long time to make the reclamation, so it would be more costly to make it speedily; but I think the estimate I have given now would be a fair estimate for making the bank speedily, and getting the material to make it.

31261. (*Chairman.*) What about the dredging from the river; I mean from the channel ? Would that not be of any use ?—That would be very well for filling in behind the bank.

31262. But it would not make the bank ?--No.

31263. It is not sufficiently stiff ?—No.

31264. (*Mr. Tatton.*) What height of bank would you require about ?—The tops of banks which are proposed are 19 feet above Ordnance datum, and height from 4 feet to 19 feet; say 15 feet.

31265. (*Mr. Stafford.*) You merely propose to make it an embankment, not to fill in ?—No, not to fill in. I think the land would be very valuable for agricultural purposes, because it is so very full of nitrogen, and it might be used agriculturally until it was required for the extension of the town, for docks, or anything of that kind; and in the meantime the portions near the city would be gradually filled up with materials available, which would not be costly at all. It would be a convenient place for the Harbour Commissioners to get rid of the stuff they dredge, instead of taking it out to sea. It would be cheaper for them; for builder's refuse and also for house and town refuse.

31266. What would be the line of that embankment ?—I have given this on the plan. It is rather different from the line I had sketched out before, because the channel has somewhat altered. That was the original one. The line of low water has somewhat altered. It will be rather an expensive thing to go into the old Channel below low water, so the reclamation I am proposing now is to be outside the line of low water everywhere.

31267. What do you think of the contention of the Harbour Board about this interferring with them ?—Well, I understand the Harbour Commissioners at the present time are favourable to reclamation as far as the city boundary. I have not got that officially. That would mean dividing up the reclamation into portions; for the purposes of estimation I have divided it into three portions; the first portion up to the city boundary, the second portion between the city boundary and the Tillysburn river, and the third portion between the Tillysburn area and the Kinnegar.

31268. You would have to get Parliamentary powers before you could do this ?—I am afraid we should, Sir.

31269. You are dealing with ground outside the district ?—Yes.

31270. You are dealing with Crown property I suppose ?—Yes, but I think the Harbour Commissioners are purchasing that from the Crown.

31271. Then you think there is nothing in the contention made by the Harbour Commissioners' Engineer, that it might in some way alter their channels ?—I do not think so, Sir.

31272. And affect navigation ?—I do not think so.

31273. (*Chairman.*) There is another point which has struck me; if you do it in three sections you will enormously increase the cost; you will not merely have to construct this single wall, but two other walls ?—You want cradge banks. It does increase the cost. There is the main bank and the cradge bank; they are given in the estimate.

31274. Would you make those anyhow ?—We would have to have at least two cradge banks. Take the Tillysburn Stream, that would have to be provided for either by culverting or putting embankments on either side of it. I prefer putting embankments. Then the other streams might be gathered to that outlet.

31275. There is the Silver Stream; as it is that would not interfere practically with it ?—One outlet would be sufficient.

31276. The Silver Stream simply drains this area but does not convey any water from other sources. The Silver Stream runs nearly parallel to the railway; it runs down hereabouts (*indicating on the Map*) nearly parallel to the railway. It is fed by that little brook there ?—They could be gathered into one outlet if we were doing the whole of the reclamation at once.

31277. (*Mr. Tatton.*) What would that land be worth for agricultural purposes when it had been reclaimed ?—Well, I really could not tell you, Sir. I suppose it ought to be worth £2 10s. an acre. I think it would be highly valuable land when it is reclaimed; I do not mean immediately.

31278. (*Mr. Stafford.*) Would you not have to fill it all in ?—No, Sir. The bulk of it is above half tide. It would drain well by putting in sluices, and with all that nitrogenous matter I think it would make excellent soil.

31279. (*Colonel Harding.*) Have you any experience in other parts; in Victoria Park I think you raised the level of the enclosed area ?—Yes, and we have also reclaimed for our sewage works 82 acres there, but that is a very much heavier bank, and it was done under what I call very bad conditions. The whole of the material had to be taken to a depot in the town, and we had to pay the railway company for putting in a special line from that depot to the embankment. We had to pay them 6d. a ton for every ton of stuff that was put into the waggons and taken there.

31280. That only affects the question of cost ?—Yes.

31281. But what was the agricultural effect, if I may so put it of the enclosure ?—Well, we have not used it for agricultural purposes.

31282. But I thought I saw a very abundant growth of something there ?—Oh yes, enormous; an enormous growth of weeds.

31283. I rather think I saw cattle also within the area, did I not ?—Yes, a man had some cattle there; they are allowed to graze.

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31284. What is your experience that would guide you in forming an opinion with regard to this larger enclosure which is proposed ?—We had about a couple of feet of house refuse spread over the top of that before that growth took place.

31285. Then Dr. Stafford would appear to be right in supposing that some amount of filling in would be required to make it into a useful agricultural area ?—Well, I hardly think the cases are similar. The slob we reclaimed on the Antrim side was practically bare of mud, it was slush; there was not a nitrogenous soil that would be found on this other side, but we had enormous quantities of rye grass growing there from the mixture of sewage sludge and house refuse; enormous quantities.

31286. (*Mr. Stafford.*) Did you get £2 10s. an acre for it ?—No, we did not try to let it.

31287. (*Chairman.*) I think it will be worth while if I were to read this Memorandum which has been given to me by Mr. Kershaw, and I think that it might go upon our Minutes.

" David Stevenson.

RECLAMATION AND PROTECTION OF AGRICULTURAL LAND.

. . . . at Sunk Island on the Humber—by warping—a deposit 3 feet deep was obtained in two and a half years . . . . three to seven years before corn and pulse can be grown. . . .

At Lough Foyle.

. . . . after the salt water had been excluded, shallow surface drains were formed and in about two years rye grass grew pretty freely. . . .

The grass was followed by oats. . . .

Deeper draining allowed the cultivation of flax and clover. . . .

Cost of intakes at Lough Foyle about £20 per acre to reclaim them from the sea; bringing the land into cultivation when reclaimed £10, say £30 per acre in all."

A reclamation in Morecambe Bay was green cropped after it had been enclosed about two years.

Estuary of the Humber—where the tidal water is highly charged with alluvial matter, 'soon after the exclusion of the tidal water the marine grasses and vegetation begin to die and decay, and in the course of one or two years fresh water grasses appear; after the lapse of about three years a tolerably good surface of pasture is naturally formed.' "

31287.* Well, I suppose one may not take it that an amount of £1 10s. per acre would pay for your cost ?—£1 10s. per acre would not pay for this reclamation.

31288. I fancy one or other of those cases would give you a fair idea as to what would happen ?—Well, I think Belfast is more favourably situated for reclamation than any of those places which have been mentioned. For instance take Morecambe Bay; it is all sand there. I know that place very well. You have nothing like the nitrogenous matter in the soil that you would have in the Belfast area. It does not pay usually to reclaim below half tide, because the height of the bank becomes so great and its bulk increases so enormously with the height that the cost of the bank prevents the land reclaimed paying. That is why I do not anticipate this would pay. It would cost about twice as much as one would expect to reclaim at half-tide. If we could get off to the half-tide embankment, we could make the land behind the embankment pay for reclamation, but as we have to go to low water, so as to cover the slob lands, it considerably increases the cost of the bank and there is no hope of it paying, not as agricultural land. But it will certainly pay in the future, because I am convinced this land will be required for the extension of Belfast, if Belfast goes on extending at the rate that it is extending now.

31289. (*Colonel Harding.*) Then, Mr. Cutler, may I ask you, do you think that this reclamation would be effective so far as this *ulva* nuisance is concerned ?—I do; I do not think it would altogether get rid of the nuisance, I mean to say there is a small quantity of *ulva* growing now outside that reclamation, that is to say at Holywood and at Cultra. How far that *ulva* contributes to the nuisance it is impossible to say, but looking to the enormous quantities growing on this land, where the reclamation is suggested, and comparing that with what one sees growing in the other places, I think the nuisance would be practically done away with.

31290. What proportion of the *ulva* would you suppose is grown within the area proposed to be reclaimed ?—Well, I should not think there is one-twentieth of it growing outside.

31291. Nineteen-twentieths of it would, by the effect of the reclamation, be at once wiped out ?—I should think so, but it is very difficult to form an estimate in the summer. In the summer time, of course, you have got tremendous quantities of this floating weed, and what one collects at Cultra and Holywood may in the bulk have been washed down with the tide from the beds between the Connswater and the Kinnegar, and on the other hand some of it may have been grown immediately on the spot.

31292. Then what probability would there be of the same conditions occurring in new areas outside this reclamation boundary ?—Well, that is what I am unable to give any information upon.

31293. (*Chairman.*) You do not think it is likely to transfer the nuisance to the Antrim side ?—Well, I cannot tell what is going to take place on the Antrim side as it is, Sir.

31294. (*Sir William Power.*) Do you think the conditions of slack water, such as exist now at Tillysburn would be reproduced at Holywood and Cultra ?—No, I do not think so; I think that the Lagan water and the Connswater will be considerably diluted before they get to Holywood; that any solids these waters have to deposit will have been deposited before they get to Holywood.

31295. Do you think there will always be a strong run of the tide down at Holywood and at Cultra ?—No, I do not think the run of the tide will be stronger, because if you diminish the upper waters the tide must be somewhat slacker. But the run of the tide is so slack now, that I do not think a small diminution of it will make any difference. The reason I think that Cultra is practically free from much nitrogenous mud, although it has got some, is from the beat of the waves on the shore, not so much the run of the tide.

31296. (*Colonel Harding.*) Then there seems to be a probability that the same conditions would not recur again outside the reclamation ?—I should think it would be improbable. Of course one has to contemplate that.

31297. As to the possible difficulties of this reclamation they might come from the Harbour Board or they might come, might they not, from landowners on the shore ?—Yes, Sir.

31298. Do you foresee any serious difficulty from the latter source ?—No, I think not, because the Railway Company's Embankment cuts off the land between the Kinnegar and ground owned by the Corporation.

31299. So that there would be no shore amenities there ?—No, Sir.

31300. And I suppose the state complained of by the Tillysburn people makes it unlikely that they would desire, in the present conditions, to make use of the shore for bathing or other purposes ?—I think it is very unlikely that we should have trouble there, Sir.

31301. What are the rights of the Crown in the matter ?—I think the Harbour Commissioners are purchasing the rights of the Crown.

31302. The question resolves itself, so far as these difficulties of reclamation are concerned into an arrangement between you and the Harbour Board ?—It seems so, principally.

31303. And possibly the areas enclosed might be of great value to that Board as well as to the city ?—I should think they would reap the greatest benefit from the reclamation ultimately.

31304. There is just one point in regard to their contention which has been laid before us that the enclosure of this large area would reduce the scour. I wanted to ask you, whether on the other hand, the material to be scoured out would not also be reduced probably in the same proportion ?—Yes.

31305. Is there not a vast quantity of this *ulva* growth which decays in winter and appears to be swept out to sea, and to some extent it may be, fills up these channels ?—It may be, but it is so very light I hardly think it would be deposited anywhere else except just where the *ulva* is growing, because I think just where the *ulva* is growing indicates the slackest water in the Lough, and if it gets away from those spots, I think it would be carried out to sea.

31306. Just another question as to a possible alternative to reclamation, and that is whether the removal of the mussel beds might not have the effect of greatly reducing the growth of *ulva*. Has your Corporation recently made any experiments in that direction ?—No, Sir. We have allocated £3,000 for the purpose. We made arrangements with the Harbour Commissioners whereby the work could be carried out. They have promised us the loan of barges also. We have put down moorings for the barges, and made every arrangement, but the weather has been so abominable we have not been able as yet to take the barges out to sea.

31307. That involves the removal to sea of the mussels, and the *ulva* being cleared away, does it ?—Either that or burying. I have been trying to make arrangements with the Harbour Engineer to bury a lot in some land they are reclaiming now on the Musgrave Channel, and Mr. Kelly has fallen in with my view, but two or three days ago he told me he thought they had stopped, but he will tell me if we may put it there.

31308. What is the area you propose to clear ?—About 100 acres.

31309. That will be a very interesting experiment ?—Yes, Sir.

31310. When do you foresee that the experiment will give its results ?—I think it should give its results this year.

31311. (*Chairman.*) That is to say you think it will very probably show that the *ulva* will not grow on this patch of 100 acres ?—If we clear the mussels there, certainly the quantity of *ulva* growing on this bed will be greatly diminished. I do not exactly know when the season is that the *ulva* spores, but if we could get rid of it before it spores that might also reduce it for other reasons.

31312. (*Colonel Harding.*) Have you heard of a small experiment which has been carried out by this Commission in that direction ?—Yes, I have.

31313. I think about half an acre was cleared ?—Yes, it is shown there on that plan which you have. That is the little half acre or acre that was cleared (*Indicating.*)

31314. What was it ; an acre or half an acre ?—I think it was an acre.

31315. It was cleared in September, was it ?—Yes, I think in September.

31316. Did you notice its condition in November ?—The Report we received was that by November the mud had been washed away by the action of the waters, and that there was clear sand ?—Yes, or an oxidised surface at any rate.

31317. I have not myself received any information since this November condition. Can you give us later information ?—Oh yes, I can give you information up to date.

31318. Then what is it ?—At the present time the conditions, so far as the sandy appearance of the surface is concerned, are the same, but there are just small clumps of mussels growing over the area. There is no quantity of *ulva* there at all. The little pieces of *ulva* are attached to the mussels where the mussels are, but these mussels I think have been washed on and rooted themselves there.

31319. It is an interesting inquiry for us to go into. Suppose the effect of clearing the mussels is to greatly reduce the growth of *ulva* in that situation, how long will the clearing of the site be effective ; how soon will the mussels return, and if they do return will it be possible at trifling expense to keep cleaning the banks, or will it be necessary to wait till after a number of years the banks have again become covered ?—Well, I was in doubt with regard to the very same thing, and it ran in my mind that at Southend the mussels have been cleared. I remembered having heard of it, and I wrote to the medical officer a few days ago, and told him that we were contemplating removing our mussels, and that I heard their mussels had been cleared, and that condition of the beach had greatly benefited in consequence. I asked how long ago the mussels were cleared ; if they were cleared at all what had been the result, and if they had recurred. He replied to parts of my questions, but did not say whether they had recurred. There was considerable improvement in the beach. Dr. Letts has that letter.

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31320. The improvement in that case has nothing to do with *ulva*, but with the mud ?—Yes, mud.

31321. It was the removal of the mud ?—Yes.

31322. And it was effective, was it ?—Yes.

31323. When the mussel was removed the *ulva* washed away ?—Yes, I used to do a little yachting down there. The shore since the mussels were removed has considerably improved.

31324. Have you ascertained what sort of cost that involved ?—No, Sir, I have not.

31325. That information would be valuable ?—I could get it, I think.

31326. Then as an alternative to reclamation, there is at present this suggestion of clearing the banks of mussels ?—Yes, Sir.

31327. And you think that at the present moment it is a little premature to form any conclusion ?—I do.

31328. In regard either to the cost or the effectiveness of your proceeding ?—Yes.

31329. (*Mr. Stafford.*) Can you use the mussels ?—I was thinking of trying that, but we might get the mussels in too large quantities for them to take them perhaps, or when they knew we had to dispose of them, probably they would not want to pay us for them.

31330. (*Mr. Tatton.*) Is there any dredging done east of the lighthouse, or is it confined entirely to the channel ?—I think the dredging is confined entirely to the channel.

31331. Therefore this question of scour does not affect anything to the east of the lighthouse ?—No, I think not. You have to consider of course whether the reclamation would alter the set of any of the currents. That is quite an unknown quantity. Only the waters of the Lough being so sluggish now I cannot conceive how there would be any material change that would affect anybody.

31332. You think the ebb tide actually does nothing to keep the channel open now ; it does not assist in keeping the channel open now ?—No, they have to dredge. That is principally in the south portion I think.

31333. What is the maximum velocity, would you think ?—The maximum ; I do not think it would be more than 1½ knots an hour.

31334. And that would practically remove nothing at all ?—No, I do not think so.

31335. Of course, the flow comes in a smaller velocity ?—Well, during spring tides you have a bigger flow of water. The ebb ? I beg pardon. Yes, the ebb tide would be somewhat greater than when the tide is coming in. You have the waters of the Lagan assisting to fill the tidal portion of the Lough, and when it is going out you have the addition of the Lagan water. Of course, it is small compared with the bulk of water.

31336. You would have that in any case after the reclamation has been made ?—Yes.

31337, (*Colonel Harding.*) Assuming for the moment that the removal of mussels will reduce the growth of *ulva*, it occurs to me to ask you what might be the possible effect of the removal of 5,000 tons of mussels in the year 1894 for sale at Glasgow and elsewhere ? Would that 5,000 tons represent a material portion of the total mussels on the beds, or would it be quite insignificant ?—I would not say it would be insignificant, but it would depend, of course, where they were gathered.

31338. Can you tell us where they were gathered ?—I cannot. (*Dr. King Kerr.*) A large amount was gathered at Carrickfergus.

31339. Then that would not affect the question at all ; that is outside the area ?—They got £4 10s. a ton for them.

31340. We may take it that the large exportation of mussels in 1894 would not affect this matter either way ? It was mainly outside the area involved by our inquiry ?—(*Mr. Cutler.*) Yes, Sir. (*Mr. McCullagh.*) I would not say mainly.

31341. Have you any knowledge, Dr. King Kerr, of any area within the *ulva* region which was cleared in

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that way ?—(*Dr. King Kerr.*) No, but my information came from Mr. Cutler's motor-boatman. When I was down the other day seeing these mussel beds, he told me he had some years ago been engaged in the business of gathering mussels, and that he got as much as £4 10s. per ton for them, so I should think it would be that export that you referred to as taking place, which took place from the Carrick shore, which is still further down. (*Mr. Cutler.*) The Carrick shore may be anywhere between Belfast and Carrickfergus. (*Dr. King Kerr.*) He meant further down.

31342. (*Chairman.*) I should like before we stop, Mr. Cutler, to ask you some questions as regards the chute. It is a wooden chute, is it not ?—(*Mr. Cutler.*) Yes, Sir.

31343. (*Colonel Harding.*) A wooden pipe ?—Yes.

31344. Is it not in very bad repair owing to age and infirmities ?—It has given me a great deal of anxiety; I have had men working upon it for the last four years, I think, constantly keeping it in order. The principal difficulties I have with it are that the piles were rather short, and occasionally parts of it would lift up. I got it in very good condition at one time, but it was not very long before the piles started giving way. The timber is as good as when it was put in, but the trouble I have had is from the rotting of the bolts. When I have got the whole thing I think in order, suddenly I will find a part of the top lift, and find part of the bolts gone. The reason I have had men working on it is that they have been waling it and putting new piles in all the way along. It is a very difficult operation, and one can only get at the work two or three days in the month, because it has to be done at extremely low spring tides. At the present time we have a burst we are dealing with, which I think will be completed shortly. We have a fairly good volume of water probably coming out in places, where wedges are required. There is nothing faulty in the construction of the chute itself, but owing to the method of construction it requires wedges in certain places. It was constructed in this way. Sheet piling was driven on each side to form a coffer dam above the tidal waters. When these were driven the ends boxed off, and then the walings to which the floor and the roof were bolted were bolted along the piles. It is almost impossible when you are driving sheet piles to get them all perfectly in line. You may get one a quarter of an inch out, and when you bolt walings on it that will leave a quarter of an inch between the waling and the side of the chute, which requires wedging. I have put on the new walings, as I thought it was more important to make the chute structurally good than to bother much about the wedging. Most of the time of the men engaged in repairing the chute has been devoted to putting on this new waling. There are several places waiting to be wedged, and there is the burst I was speaking of that occurred about a month ago.

31345. Is it very leaky ?—I do not think it is compared with the volume going through the chute. It is 16 feet wide and 4 feet deep. The only places where one can detect leaks is on the top of the chute where the wedges have to be put in.

31346. (*Chairman.*) You really think a considerable volume comes out of the outlet ?—There is no doubt about it.

31347. (*Colonel Harding.*) Is it silted up at all ?—No; there are 5 or 6 inches, but within 200 or 250 feet of the mouth the top of the chute is open, and I have men out there every tide, when it is possible, to clear out the deposit as it washes down. Since we have been sedimenting the old deposit is constantly down to the mouth. I leave this place open to let the men get at it.

31348. I suppose it is a fact that there is very considerable leakage on the way ?—Only at this place.

31349. It is very evident to anyone walking along the shore ?—Yes, but the leaks come from these unwedged places.

31350. What are the prospects of the future of the chute ? It has been a constant source of expense and trouble to the Corporation of Belfast; is there any prospect of the chute being replaced by a more satisfactory structure ?—To construct a new chute would be a very expensive business.

31351. (*Chairman.*) Could they not make a cast iron pipe, or a steel pipe ?—One would say with concrete. As I say it would be a very expensive business, and I did not advise my Corporation to do anything in the way of a new chute until we know what we are going to do with the sewage. It occurred to me that if we had to purify our sewage completely, the chute would not be necessary, whereas if we only sediment it, it will be necessary. The money may be thrown away, and rather than throw the capital amount away, I thought it better to spend money annually trying to keep the chute in order.

31352. Would you consider yourself at liberty to answer the question I put to you just now ? What would be the nature of the substitute you would put down if it became necessary to put one down ?—It would be either iron pipes or ferro-concrete tubes.

31353. Are you at liberty to give us any idea what cost would be involved ?—I have not estimated it.

31354. Have you any idea ?—I suppose, roughly, £20,000.

31355. Would that be a prohibitive cost in connection with this very great expense you have to go to in other directions ?—I do not mean prohibitive, but what I mean is costly, if we had to put it down and it was not necessary. Suppose we were to purify our sewage completely, I do not think the chute would be at all necessary.

31356. Then do you not think the expenditure of £20,000 on an effective chute to convey your sedimented sewage to the Whitehouse Roads, deep water, would be a very important work to carry out, and one likely to produce very great good ?—I do not think we would get any better results than we are getting now, because, although one can detect considerable leakage going along the chute, the volume is small compared with the size of the chute. The chute is 16 feet wide and 4 feet deep. Still, if we were stopping at sedimentation, I should say certainly we should put in a new chute.

31357. (*Chairman.*) And lengthen it ?—I hardly think so. The top of the chute is rarely uncovered now except at the very lowest spring tides. I do not think there is any necessity to lengthen it.

31358. (*Colonel Harding.*) But it is alleged, Mr. Cutler, that a large proportion of your sewage is discharged between your sedimentation tanks and the far end of the chute, and that such portion as is so discharged passes down the Seal Channel, and gets delivered over the Tillysburn area ?—That I think refers to the time before the chute was cleaned. That was so. The chute was so weak in many places, and deposit had occurred in the chute, which did not allow sufficient area for the volume to go forward and it lifted off the top of the chute somewhere near the Seal Channel, and in spite of all we could do we could not get it sound as long as that deposit was in the chute, and for two or three years the sewage was going out and on to the slob near the Seal Channel.

31359. You say to us that the condition has greatly improved ?—It does not exist now. All the water coming out of the chute now is along the sides of the chute, pooling up where those wedges want putting in.

31360. Although you say they are considerable, they are inconsiderable compared with the total volume ?—I think so.

31361. I suppose since you have sedimented your sewage, you have less trouble with the deposit in the chute ?—I say we have no trouble with deposit in the chute at the present time. We gather the deposit in the chute about once a month, and it gets less. We knew there was some in the chute, five or six inches, in spite of all our cleaning, because the cleaning was before the sedimentation was started, but since the sedimentation that is getting less and less.

31362. Then your difficulties with a properly constructed chute would probably be scarcely appreciable in future, with sedimentation ?—I think not, because if I constructed a new chute, I would construct it in two separate conduits.

31363. Can you tell us at the present moment whether there is any discharge independent of the chute at any time from your Works ?—Yes, Sir, there is.

31364. It is alleged you have a channel from one of your reservoirs that is occasionally used, and a considerable discharge takes place at times ?—Yes.

31365. What is that discharge, and when does it take place ?—If you look, Sir, at the first page of that you will see the volume of sewage treated there. The second item, the average daily, is 19·83 millions; that is for the twelve months, compared with 15,500,000 of daily dry weather flow. That is actually what has gone through the sedimentation tanks, and measured by automatic gauge it gives a record diagram, from which the area is taken out every day and the quantities put down. You will see the quantity treated every day in these sheets of analyses, or rather every week. From that, Sir, you will see we have treated a very large proportion of storm water to have got the average up to nearly 20,000,000. We can pump about three times our sewage flow into the tanks. It is only when the pumps will not take the total quantity of water coming down that we have to discharge into the pond at the side of the tanks.

31366. That is really a storm overflow of beyond three volumes ?—Yes.

31367. Is that so ?—That is so, and that at the present time has to be discharged through a penstock on to the slobland, because there is no connection with the chute.

31368. May I take it then that at the present moment the Corporation of Belfast is sending through the chute up to three volumes of its dry weather flow ?—Yes.

31369. That there is discharge from the thing I have referred to, except when you get beyond a certain volume ?—That is so. Probably I am not correct in saying that when the men are working on the chute repairing; that is at the low spring tides. On such occasions we have to stop using the chute. It is only for two or three hours at a time. The flow on those occasions discharges into the side pond, and that will be a small addition to the quantity I have stated.

.31370. So that the ineffectiveness of your chute adds to the frequency of this irregular discharge ?—Yes, Sir, but it is a bagatelle compared with the quantity treated.

31371. (*Chairman.*) Then again it has been brought before us that the storage area is not sufficient; that you ought to have larger reservoirs and tanks. I presume you very often discharge; in fact at all states of the tide, do you not ?—At the present time, because we are carrying out the work for which we have borrowing powers; that is to construct extra sedimentation tanks. We have sedimentation tanks now the volume of which is 4,500,000; we are putting in another 3,250,000 for sedimentation.

31372. (*Colonel Harding.*) When will they be at work ?—I think the contractors have another six months to run yet. They have only just started construction. The contract has been let for the construction of the tanks, and the contractor is at work now.

31373. Will they furnish the capacity which was suggested by the Health Commission ?—Yes, Sir, it gives us twelve hours' flow for sedimentation, and then we are constructing ponds for the storage of the effluent so that we shall only discharge through the first three-and-a-half hours of ebb.

31374. Then the question arises, will your present conduit be capable of discharging within the permitted hours, not only the dry weather flow, but this additional storage ?—About three times. We are storing about three times, and the chute would discharge, except when the ebbs are bad, at the rate of three times the daily flow; but I do not think it matters materially if we cannot always discharge it in one tide, because when we are providing for storing three times the daily dry weather flow for eight hours, I think there will be very few occasions where you will have rainfalls of that extent over such a long period, so that what we cannot discharge in one tide, we will probably be able to discharge the next.

31375. And you are providing that enclosed area for the purpose of sewage storage ?—Yes, Sir.

31376. Is that going on now, or is it simply a thing you propose to do ?—Oh, no; one pond is formed; the western pond is formed. Men are now concreting it. The eastern pond has been formed a long time, that is the one we use for storm purposes. It is to be concreted, but we cannot do that until we have got the western pond available.

31377. Then within what period of time do you anticipate that the works which have been sanctioned by the Local Government Board—and which I suppose are pretty much the same as were recommended by the Health Commission—will be fully carried out ?—They will be completed this year.

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31378. The whole of them ?—Yes, Sir.

31379. (*Mr. Tatton.*) Shall you precipitate or simply settle the sewage ?—Settle it, Sir.

31380. (*Colonel Harding.*) I see you are sending out 180 tons a day of sludge to sea ?—Yes, Sir.

31381. (*Mr. Stafford.*) You are doing that now ?—We have been doing it since October, 1908. I thought it rather more, but that is what it averages out.

31382. Are you making any provision for the possibility of precipitating ?—Well, it would not be difficult to add the plant. We have considered that in laying out the scheme, and there is plenty of ground to put down any apparatus we require for precipitation plant.

31383. You think it might be a very wise thing to do in case you had to precipitate later on ?—Yes.

31384. (*Chairman.*) There is a question I should like to ask Dr. Adeney, if he is aware of any evidence that can be given on the growth of *ulva* in crude sewage or in dilute crude sewage, and in the diluted sewage effluent ?—(*Dr. Adeney.*) Well, I have no experiments of my own to refer to, Sir. Of course, I have had the *ulva* nuisance constantly under my notice, being a resident near Dublin. We have it on several parts of the coast, and wherever my observations have been made, especially at Clontarf—the old condition of Clontarf foreshore was an extremey good object lesson. There you had open sewers discharging on to a flat foreshore and wherever you had these open sewers discharging there was a tendency, if the discharge were sufficient, to produce a state of gross pollution. Then immediately round that, where the pollution became less serious, in other words where I would say aerobic fermentation was going on, a luxuriant growth of *ulva* was to be noticed.

31385. It is dilute crude sewage ?—What I think the most favourable condition to be is the deposit of sewage solids. They ferment slowly and give off the food material in a concentrated form, which the *ulva* receives before it becomes diluted with large volumes of sea water..

31386. Do you think any material advantage would be gained from filtering the deposited sewage ?—From Belfast ?

31387. I am speaking of Belfast.—I have gone into that matter quite recently, within the last fortnight, and I have come to the conclusion that there would be no benefit whatever, certainly not if the scheme of reclaiming the loblands, as suggested by Mr. Cutler, be adopted. I went over West Bank with Mr. Cutler and Dr. Hawthorne the other day, and there was no sign of serious pollution or of deposit of solid matter near the buoy No. 10 on the West Bank. There is really no sign of serious pollution there at all, and I do not understand myself how solid matter could get beyond the Channel. No doubt liquid matter might get over, but owing to the shallowness of the water it would become mixed with the tidal water very rapidly and become very much diluted. I do not think it would by itself seriously affect the southern shores of the Lough.

31388. (*Mr. Stafford.*) It gets into the Channel, does it not ?

31389. (*Chairman.*) Which channel ?

31390. (*Mr. Stafford.*) The Victoria Channel ?—The Victoria Channel. You see the experience of Dublin is very suggestive. In the old times when sewers were discharging the whole of the Dublin sewage into the river area in a crude state, the solids were all deposited within the river area, and that was with certainly double the tidal current and in the direct tidal current. No deposit of sewage solids was noticeable about one mile below O'Connell Bridge, so that I do not see myself how a lateral deposit, as it were, could extend beyond the deep water channel in Belfast.

31391. As a matter of fact, has it not gone into the deep water channel—as a matter of known fact ?—That is quite possible.

31392. Have not the Corporation had to pay the Harbour Board very heavily for this ?—That is Belfast.

31393. Yes ?—Well, I do not know. (*Mr. Cutler.*) Yes, contrary to my advice.

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31394. But they have had to pay £6,000 for the damage done to this channel ?—Yes, Sir.

31395. I am sure they did not do that in Belfast without very good reason ?—(*Dr. Adeney.*) My point is this. The Belfast sewage has been subjected to sedimentation since 1908. I was much surprised at the beneficial results which have followed. Furthermore, the recent discovery of the fact that the chief nursery for the *ulva* is situated on the slobland, lying between the Kinnegar and Connswater, has led me materially to alter my views as regards the extent to which the sewage from the wooden chute has contributed to the *ulva* nuisance that has been experienced along the southern shores of the Lough. Before this discovery and before my recent visit to the Lough, I surmised that the *ulva* largely grew in the attached condition on the West Bank, and drew its food supplies from the sewage discharged from the chute, but on examining the West Bank a few days ago, I could discover no indications of the growth of *ulva* upon it, and it now seems to me that the greater portion of food material for the *ulva* growing on the bank in the Tillysburn district must be coming from elsewhere, probably from the Connswater and from the Lagan. That is what occurs to me. I mean the material which goes to promote the active growth of this weed on the slobland lying between the Kinnegar and Connswater.

31396. But the Connswater and the Lagan have been discharging there for very many years ?—Yes.

31397. A great many years, and what was the condition of affairs upon that Tillysburn bank before Belfast sewage was taken out of the Lagan ?—I do not know, I can only speak from the present conditions so far as I have observed them.

31398. Mr. Cutler, could you not tell us that either ?—(*Mr. Cutler.*) No, Sir; I think there has been a nuisance there for a great many years, but whether it has become more acute or not I cannot say. People say it has, but I think they are more fastidious than they used to be.

31399. (*Colonel Harding.*) Assuming that there is a discharge from your sewage works which would pass down the Seal Channel, do you think it is possible that the suspended matter from such discharge would be carried across the Victoria or the old Channel, and get deposited on the Tillysburn area ?—I do not, Sir, and moreover I do not think the sewage is carried that way. I have some charts here that are rather interesting bearing on that very point.

31400. I should like just to pursue this very point. You know that it is alleged by certain witnesses who have come before us that the muddy deposits on the south shore, the Tillysburn area, do not consist merely of food vegetable matter, but consist partly, and they say largely, of direct sewage deposits from the great main outfall; that is the allegation ?—Yes, Sir.

31401. I merely wanted your opinion as to how far it is possible for the suspended matter, from your main outfall, whether it be discharged within the area of the Seal Channel, or whether it be discharged in the Whitehouse Roads to get across there, what is the condition of the suspended matter. It is one point of alleged evidence brought before us that considerable quantities of fœces were found on the south shore. I would like to ask how it is possible for such to survive your pumping operations ?—It is not, Sir. You have the pumping and the screening operations, and, of course, in addition you have the sedimentation, and it is impossible for anything of that kind to pass.

31402. But in the period before you carried out your sedimentation would it be possible then ?—No.

31403. For fœces to survive the ordeal of pumping ? It would not, Sir.

31404. Did you pump the whole of what passed into the Lough ?—We did not.

31405. It would be possible then for such matters, in former years, to have reached the south shore ?—I do not think so, Sir.

31406. Which had not passed through the pumps ?—I do not think so, Sir. (*Dr. Adeney.*) In my experience it would be absolutely impossible for any of the domestic sewage to survive in bulk form such a long tract of water.

31407. I wanted the opinion of Mr. Cutler upon this, because it has been urged that the muddy deposits on the south bank are largely due to direct sewage contamination from the other shore, and evidence has been brought before us that fœces in the natural condition were found there on the shores. Do you think it is possible for such to have come from the main discharge of Belfast sewage ?—(*Mr. Cutler.*) I think it is totally impossible.

31408. Then will you tell us why ?—I know the allegation has been made before by the Harbour Engineer, and I think by Mr. Harrison's advisers, and because of the allegation I had float experiments made to determine that very point, and here is a chart, Sir, showing some float experiments. (*Chart produced*).

31409. Are you referring to some recent float experiments, or to those which were carried out by you and Professor Letts ?—No, Sir, since then. I started the floats from the part of the chute where the Seal Channel crosses it at every half hour of the tide, and if you look on that chart, Sir, you will see where those floats go to.

31410. (*Chairman.*) It might be well to mention to you, Mr. Cutler, that we have had data given to us of float experiments carred out under similar conditions to these where the effect was quite contrary to what is shown upon the map you have submitted to us ?—Well, I will show you something besides that presently. I was there when these float experiments were made. You see several of the floats approach the Victoria Channel near the Sea Channel and stop there, that is on the latter part of the tide, they did not go into the Channel at all. I sat in a boat about an hour and a half, stayed there about half an hour after the tide had changed. Five or six of the floats from memory had got as far as the junction of the Seal Channel with the main channel, and they stayed there bobbing about and did not move any further. I came to the conclusion then, Sir, that the current in the main channel was stronger than in the Seal Channel, which would not allow them to pass.

31411. (*Sir William Power.*) What were the conditions of wind then ?

31412. (*Mr. Stafford.*) The wind was east ?—The wind was east, and it was very light.

31413. (*Colonel Harding.*) From what period was this experiment ?—From high tide to low tide.

31414. One day ?—Yes, Sir.

31415. It is quite conceivable that, tried under different conditions, different results would be obtained ?—Quite so. I thought so myself, but to try and determine this point I carried out another series of experiments. I put floats into the Seal Channel about 100 yards back from the main channel, and this is the result I got then, Sir (*indicating on chart*).

31416. (*Mr. Stafford*). What was the state of the wind then ?—It is given there.

31417. "Wind south-west, very light." What is the prevailing wind ?—I think a south-west, Sir.

31418. (*Chairman.*) Is it really worth while spending time on this ? The question that interests us is, does Mr. Cutler think it necessary to go past sedimentation ; does he want filtration ?—I want what is best for Belfast.

31419. (*Mr. Stafford.*) The only interest really is the other series of float experiments we had on the other side.

31420. (*Chairman.*) I think we can simply say there is evidence on both sides ; some float experiments show it going across the Victoria Channel.

31421. (*Mr. Stafford.*) They would look like trained floats ?—The first float experiments were made with loaded wooden floats, and they were standing two or three inches above the water with a very small flag. Those were the experiments carried out with Dr. Letts, but I was satisfied the wind had a considerable influence on those floats. After that I used oranges, because the specific gravity is very much the same as water. We had the greatest trouble in following them. That was the nearest approach I could get to a float which would not be influenced by the wind.

31422. (*Colonel Harding.*) Assuming for the moment that at times there are conditions which would carry matters from the main outfall across both Channels to the south shore, do you think it is possible from your experience of the suspended matter in the sewage, that the sewage could travel so far without being deposited on the way ?—I do not think so, because the silt carrying capacity of a water is dependent on its velocity. The greater the velocity the greater the silt carrying capacity it has got. The velocity in the water over the slob is less than the velocity in the channel naturally, and any solids which would not get deposited in the slack water could hardly be deposited in the quicker running water in the Channel. No ; if there was any fœcal matter discovered on that shore, Sir, I should say it came from the discharge from the shipyards, or it might have come from Connswater, and those are the only two places I could conceive where fœcal matter could come from, unless it came from Holywood or Cultra or the Sydenham outlet.

31423. Then, are we to take it that in your opinion the suspended matter, at least from your discharge, does not affect the condition of the south shore ?—It does not, Sir. I think the character of the mud without much observation would prove that our solids were deposited on the Antrim shore and this would be patent to anybody walking along the chute, from the smell of it. But you never get the same characteristic smell on the southern shore. I have never noticed anything like it. You may get particles of fœcal matter showing there ; it will only be from Sydenham or Connswater, or the shipyards or Holywood or Cultra.

31424. Now you have obtained some experience in sedimentation ; do you suggest to us that in your opinion it will not be necessary for your Corporation to carry out processes of filtration ?—I think, Sir, if you go any further it will not stop the nuisance.

31425. You think that further purification would not reduce the nuisance from *ulva* decaying material ?—I do not think so.

31426. (*Chairman.*) I think Dr. Adeney is of the same view ?—(*Dr. Adeney.*) Yes.

31427. (*Colonel Harding.*) And I would like to know whether you include the substitution of an effective chute in your proposal in forming that opinion ?—(*Mr. Cutler.*) It does not really influence my opinion, because I think the chute is acting efficiently enough in that respect now, but I would include a new chute if we were not going further than sedimentation ; I would certainly say, put in a new chute. We will have to put in one before long ; this one may collapse, and if we put in a new chute it will be available.

31428. Given sedimentation, given regularity of discharge, and given an effective chute, your opinion now is that it would not be necessary for the Corporation to carry out processes of filtration ?—I do not think so, Sir.

31429. (*Chairman.*) You will combine those with the reclamation of the slob lands ?—Yes, Sir, or with the collection of the weed. I think my corporation should carry out anything with regard to the sewage that would reduce the nuisance. If it is your opinion that it is our sewage that causes the nuisance, I say by all means purify it if it will get rid of the nuisance. It is the nuisance that we want to get rid of, it is not that our sewage is in the Lough.

31430. (*Mr. Stafford.*) Do you say the sewage has nothing to do with the process ?—I do not say that. We are putting nitrogen into the Lough ; nitrogen in any form causes the weed to grow ; if we did not put our sewage in you would still have nuisance from the *ulva.*

31431. (*Mr. Tatton.*) What head is required in the chute to get that three volumes through ?—It varies considerably ; I cannot tell you that from memory, but our surface water in one of our ponds will be 17 and in the other 15, and the average high-water spring tides is 13·25.

31432. What is the level of the chute ?—That hardly affects the question, but it is below low water mark ; the bottom of the chute is about ordnance datum.

31433. Do you get pressure on the chute ; you have to put it under pressure to get the water through ?—Yes.

31434. (*Mr. Stafford.*) It has been alleged you have not sufficient head on that chute, not sufficient pressure, that it does not clear the chute ; you have not sufficient head on it to clear the chute ?—At the present time we are discharging continuously, and it only gives a very small velocity. If we discharge during three and-a-half hours of the ebb we will considerably increase that velocity.

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31435. (*Colonel Harding.*) Would your chute stand it ?—That is what I am doubtful about, but we will make it stand it.

31436. (*Mr. Stafford.*) Would it not blow the top off ?—I do not think it will.

31437. When was this chute cleaned and put in such excellent order ?—It was cleaned some twelve or eighteen months ago.

31438. That is before the visit of the Commissioner ?—Yes, Sir ; I think you saw a considerable quantity coming down the sides of the chute. I admit it is coming out too ; it is coming out through these places where it was not wedged.

31439. We had some considerable doubts of the amount coming out of the end ?—It looks much, but it is not much considering the size of the chute ; 16 ft. by 4 ft. I went along it after you were there, half the chute had been rewaled all through, the old wedges had been taken out ; it had not been rewedged.

31440. (*Colonel Harding.*) What have your Corporation spent over the repair of the Chute, during the last three years ?—Oh ! I suppose about £5,000.

31441. That would be about a quarter of the cost of the new chute ?—Yes, Sir. (*Dr. Adeney.*) Last week I went down this chute about two-thirds of its length. There was one big leak I noticed, and a number of very small ones ; there was one decided leak for a long distance. (*Mr. Cutler.*) That is one which has occurred during the last month. We had a lift on the chute about a month ago.

31442. (*Mr. Stafford.*) It did not impress any member of the Commission very favourably, I may say ?—I am sorry, Sir ; it has been a baby of mine for the last four years.

31443. It was suggested yesterday that you ought to carry the chute out to the 1 fathom line. Is there any benefit in doing that ?—I do not think so, Sir. I do not think that there is any better possible position for the chute than its present position, and I do not think we gain anything by taking it out further ; it could not possibly benefit the County Down shore.

31444. You would get a deeper water ?—Naturally, we would get a deeper water.

31445. And a better current for taking it away, that is the suggestion ?—Well, I am not prepared to speak as to the current, because I have not carried out float experiments with regard to that, but I do not think there would be any benefit in taking it out further.

31446. You might possibly look into the question whether there would be any benefit in carrying it out further. I think it was rather impressed upon us that there might be a distinct benefit in carrying it out further ?—I will. The benefit would only be to the Antrim shore, it would not be to the County Down shore.

31447. Another point of criticism was the tanks, the capacity of the tanks ?—The present capacity ?

31448. The capacity when you have furnished your present works ?—Well, we were asked for a twelve hours flow and we are putting it in. And there is another thing to be considered if we are to pond our effluent for eight and-a-half hours, surely there ought to be sufficient sedimentation. In my opinion the tanks are too big. You have a second period of sedimentation in the ponds. We have far too great a capacity for sedimentation, in my opinion.

31449. Just one other point. The Sydenham and Knock sewage, taking that, what is your view about that ?—I am remodelling my scheme now. Members of my corporation have talked it over, and I have got instructions to prepare a scheme for taking the Sydenham sewage into the main outfall works.

31450. (*Colonel Harding.*) The whole of it ?—Yes, the whole of it. The capacity of the sewers in the city is too small to take the portion of the Sydenham drainage that they are taking now. That frequently leads to flooding, but what I am proposing to do if we decide upon taking it to the main outfall works is to take the

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whole of the sewage to the Sydenham pumping station which is already erected.

31451. (*Mr. Stafford.*) The whole Sydenham and Knock ?—Yes, the whole of it to that. To lay the pumping main from that station right away to the Queen's Bridge, or near the Queen's Bridge, where the syphon crosses the Lagan. And then in connection with the flood scheme I have recommended my corporation to carry out, there was to be a pumping station on the Lagan syphoned so as to relieve——

31452. I do not think you need go into the details; there is a possibility of bringing it in ?—Yes, Sir.

31453. And you probably would find you would have to make new sewers, as the capacity of the present sewers are insufficient ?—Yes, Sir.

31454. (*Colonel Harding.*) You have abandoned the Sydenham scheme which was proposed two years ago ?—No, Sir, it is not abandoned; I am preparing a scheme for dealing with it at the main outfall works. When I have got that completed and the estimate prepared, then my corporation will consider the possibility of doing it.

31455. (*Chairman.*) We are very much obliged to you for so kindly coming before us and giving us so much information.

NINETY-NINTH DAY.

Thursday, 17th February, 1910.

PRESENT:

Sir WILLIAM H. POWER, K.C.B., F.R.S. (*in the Chair*).
Colonel T. W. HARDING, J.P., D.L.
Mr. T. J. STAFFORD, C.B., F.R.C.S.I.
Mr. R. A. TATTON, M.Inst.C.E.
Mr. F. J. WILLIS (*Secretary*).

ALSO PRESENT:

DR. GEORGE MCGOWAN.
Mr. C. C. FRYE.
Mr. G. B. KERSHAW.
Professor E. A. LETTS.
Mr. E. H. RICHARDS.

Mr. ROBERT THOMPSON, M.P., the Chairman of the Belfast Harbour Commissioners; and Mr. W. REDFERN KELLY, M.Inst.C.E., the Engineer-in-Chief to the Belfast Harbour Commissioners, called in; and Examined.

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31456. (*Chairman.*) I have to thank you for the facilities you gave our officers and ourselves when in Belfast ?—(*Mr. Thompson.*) It was quite a pleasure to me. The City Corporation did not wish us to interfere in this matter beyond a certain point, so we kept out of the way, as it were, when you were in the town.

31457. You, Mr. Thompson, are Chairman of the Harbour Board Commissioners ?—Quite so.

31458. And, Mr. Kelly, you are Engineer to the Board ?—(*Mr. Kelly.*) Yes, Sir.

31459. We have received your statement, and have all of us, I think, studied it. It will be convenient if you put that in; we will get it on the Minutes, and then we can discuss the various questions as they arise, not necessarily in the order they are here, but in some other order perhaps ?—Yes, Sir. (*The following Statement was handed in.*)

1. As regards the causes of the nuisance which is experienced at times in the case of Belfast Lough, there can be no doubt that the primary cause of the nuisance is the improper disposal of the sewage of the city; and the secondary cause is to be found in the rapid and formidable growth of the *ulva latissima*, a prolific seaweed, which, as is well known, thrives upon sewage matter.

2. And as to the second point: The means whereby the nuisance can be avoided is, naturally, the removal of the cause.

The improper disposal of the sewage of the city is the result of the imperfect methods adopted by the City Corporation in the carrying out of the Main Drainage Scheme, for which they secured Parliamentary powers in the year 1887.

By the Main Drainage Act the City Authorities made themselves responsible for, among other things, the construction of a proper and sufficient storage reservoir for the sewage pending its discharge within certain well-defined statutory periods into the tideway.

They also bound themselves to provide a proper and sufficient outlet culvert, from the Main Drainage Station, whereby the sewage of the city was to be conveyed into the tideway in the vicinity of Whitehouse Roads. This outlet culvert took the shape of a timber structure, commonly known as "the chute," and consisted of a rectangular boxing divided by a mid feather into two compartments, each of which was to be 8 feet wide by 4 feet in depth, and the total sectional area of which chute was to have been 64 superficial feet.

The storage reservoir was only designed for the impounding of 5,000,000 gallons; no provision having evidently been made for the natural increase of the population.

The chute was, from the first, imperfect in design, and in construction, and completely failed, becoming absolutely choked up in the month of December, 1904.

The failure of the chute led to the escape of the sewage into the tideway, along all points, throughout its length, other than the point of discharge provided for by the Act of 1887.

The sewage thus released flowed over the sloblands, large quantities finding their way into the Seal Channel, and thence to the Victoria Channel, Musgrave Channel, and Old Channel, eastwards of the Victoria Channel, and immense quantities of sewage sludge were deposited in these channels and on the sloblands adjoining.

The deposits in the navigable channels had to be removed at the cost of many thousands of pounds; but the deposits on the sloblands provided that nourishment which is so essential to the growth of the evil weed known as *ulva latissima.* It would, therefore, seem to be scarcely necessary to go farther afield in order to discover the palpable cause of the nuisance which forms the subject matter for the forthcoming enquiry.

Besides the sewage matter which by extrusion from the various openings in the dilapidated chute found its way into the tidal waters of the Lough, the City Authorities have been obliged, owing to the failure of the latter, and the ever increasing quantities of sewage to be dealt with, to discharge at any, and at all times, as might be found by them expedient, crude sewage into the tideway, notwithstanding the obligation imposed upon them by the 1887 Act, to only discharge sewage during certain well-defined periods, and always whilst the tides were on the ebb.

Were it not for the extensive tracts of sloblands on both sides of the navigable channel which were alternately exposed to tidal and atmospheric influences, and upon which this improperly controlled escaping sewage became precipitated, the nuisance would of course have been, comparatively speaking, trifling; yet the existence of such a vast spread ground had to be counted with, and measures to prevent the indiscriminate escape of the sewage should have been resorted to by the responsible

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authorities before the evil became so serious as it has actually proved to be.

As to the remedy or remedies, for the evils complained of:—

The most effective remedy, and the most practicable would be the treatment of the sewage at the Main Drainage Works in such a manner as that the highest possible and reasonable standard of purification of the effluent could be attained before discharging it into the tideway.

Such a standard of purification could not conceivably be attained by precipitation alone.

Again, a remedy might be found in the reclamation of enormous tracts of foreshore, but, to be effective, such reclamation would require to be carried beyond Cultra, on the County Down side of the Lough, and Macedon Point, on the County Antrim side of the Lough. The expense incurred in the carrying out of such an extensive reclamation would render such a scheme utterly impracticable, independent of the injurious effects which such a vast reclamation would have upon the navigation of the approaches to the inner harbour.

In dealing with matters as they now stand, the City Authorities find themselves in a very difficult any trying position, as, in order to dispose of the sewage of the city in the manner prescribed by the Act of 1887, the existence of the outlet chute becomes a practical necessity. This chute is, however, useless for the purpose for which it was originally intended, viz., that of carrying the sewage of the city into deep water in the vicinity of Whitehouse Roads. If the chute must still be resorted to as an outlet for the partially purified effluent, it would require to be replaced by a staunch and reliable structure, composed of either metal work or reinforced concrete, and its sectional area would also require to be increased.

The existing chute, is under present conditions, insufficient to deal with the sewage discharge during the statutory periods, and it has a strong tendency to silt up.

To the failure of this chute may be attributed, to a very large extent, the existence of the nuisance at present under consideration. In consequence of the disruption and the exudation of the sewage matter through the various rents in the structure, large volumes of crude sewage have been spread over the sloblands, and much of it has, as well, found its way into the navigable waterways of the harbour.

Owing to the insufficient capacity of the chute, discharges of crude sewage direct into the tideway in the vicinity of the Main Drainage Outfall Works, naturally resulted and, as one of the consequences of the disruption of the chute, sewage has been, for many years back, conveyed through improper channels to various points of the foreshore on both sides of the Lough, and became precipitated upon those lands in slack water.

As to the question of the effect which extensive mussel beds may have on the promotion of the growth of the *ulva*, as has been suggested by experts associated with the Royal Commission, there can be no doubt that mussel shells would afford good anchorage for the weed, but it must not be forgotten that the *ulva* has been found to thrive in places where there are no mussels to be found. Sand affords a good anchorage for the *ulva* but not perhaps so good as would the mussel shells. The growth of the *ulva* is more in evidence on a sandy foreshore than it is on a soft, sleetchy, or muddy slob. This weed invariably thrives better in situations where it can secure a good anchorage.

Ulva latissima will grow on one place on the foreshore, and, on being disturbed by atmospheric or tidal influences, or both, will be carried to another place where it will be heaped up, and, by the natural process of decomposition, will become a serious nuisance, more especially during warm weather.

31460. As regards No. 1 of the statement, you speak of the primary cause of the nuisance being the improper disposal of the sewage of the city; and the secondary cause is to be found in the rapid and formidable growth of the *ulva latissima.* Then you say: "The deposits on the slob land provide that nourishment which is so essential to the growth of the evil weed known as *ulva latissima.*" Therefore, I take it that your attitude as to that is something of this kind: that in the view of the Harbour Board the County Down foreshore nuisance, of which we have heard so much, has been due less to sewage pollution or to *ulva* growth, acting each as a separate agent, than to both as agencies operating in conjunction? The sewage pollution, *per se*, is not likely to have been the cause of pronounced nuisance, and that on the other hand *ulva* would not have become extra abundant and unusually vigorous, and as a consequence the cause of definite nuisance, but for the exceptional degree to which this weed has been nourished by sewage? Is that practically your attitude? We have heard that from various sources, not altogether unanimously, but it has been the contention which has been constantly before us?—(*Mr. Thompson.*) Quite so. We believe that to be correct, Sir.

31461. Then I go on to the next point. Further, we understand that the Harbour Commissioners urge that the Belfast Corporation, through disregard of their obligations under Acts of Parliament in this matter of sewage disposal, have caused, or at least have conduced to, the County Down foreshore nuisance, and in addition have caused no small detriment to the navigation channels under the jurisdiction of the Harbour Board, by abundant deposit in these channels of sewage solids?—We were obliged to carry on dredging operations to keep the channel clear to a very large extent.

31462. That being the case, it would be convenient first to take the obligations undertaken by the Corporation in the matter of sewage disposal, and the degree to which the Harbour Board consider those obligations have been neglected or evaded; and having done that we might take the result of such neglect or evasion; (*a*) as conducing to the foreshore nuisance; and (*b*) as causing silting up of the navigation channels. Then will you proceed first to state what you consider have been the obligations in the matter of sewage disposal of the Corporation?—In 1887 the Corporation took powers to carry out a main drainage scheme. The population of Belfast was much smaller then than it has come to be since. I think the population at that time was only 247,000, or thereabouts. They erected pumping stations for lifting the sewage to pass down a chute. That chute is a wooden structure about a mile long. Then there was a cut made from the mouth of the chute, about a quarter of a mile in addition to that. With the increase in the population, and still further by an increase in the number of houses that were contributing to the sewerage of the Town, in 1889, under the Act they obtained, they took powers to compel small householders to put in water closets, and I think 22,000 water closets were introduced at that time in that way. Well, that increased the volume of sewerage immensely. There was no adequate provision, or no provision, made for the increase passing through this chute; consequently it became unable to vent the quantity of sewage, and it burst up, and the sewerage overflowed all round, and it was passed up by the incoming tide instead of going out, I should say, at high tide, or a little after high tide, which we thought the receding tide would have washed out to sea; but it passed out of the chute at all states of the tide, and consequently it was passed by the incoming tide on to the slob lands all round, and became deposited there more or less; and we believe that is the cause of the growth of the *ulva latissima* about which we have had so many complaints, and which causes such an offensive smell.

31463. Under the Act of 1887 did the Corporation proceed to re-construct the sewers of the town, and provide intercepting sewers to catch the previous outfalls to the river?—They did make an honest attempt at that time to broach a system, but you see that system is not sufficient for the larger population. The population is now about 380,000, without any increase practically for the outlet of the sewerage.

31464. That scheme provided for that part of the City on the County Down side of the river, I suppose, did it not?—There was a sort of provision made; I do not say it was a complete provision, but there was a sort of provision made for all the sewerage of the city at that time.

31465. Then about what date had the intercepting sewer been constructed, and the sewage brought down to the site of the present Outfall Works?—Just as they could carry out the works after 1887; the main drainage scheme was commenced shortly after that, and as they could carry out the works, continuing it till they got the system complete. They have two pumping stations; well, really this is about five years after.

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31466. Then the Belfast sewage was delivered by the intercepting sewers at the Outfall Works ; about 1892 ?—That brings us to 1892.

31467. The chute was not in operation then, was it ?—(*Mr. Kelly.*) Oh, yes, it was.

31468. About 1892 ?—About 1891 the chute was in operation. Well, possibly about that time ; I am not very sure about that. If you have evidence from the Corporation that it was not, I would not say it was.

31469. We had a witness the day before yesterday who spoke of it coming into operation about 1893 ?—(*Mr. Thompson.*) That possibly may be correct. It took that time to carry out the works. They got powers in 1887, and until the works were ultimately completed. (*Mr. Kelly.*) It would be about that time.

31470. Assuming the sewage was brought down to the site of the present Outfall Works before the chute came into operation, where was it discharged ?—Prior to the formation of the chute and the formation of the new sewage system, it discharged into the High Street sewer near to the centre of the city, into the River Lagan. That was the place where the sewage was discharged in great volume.

31471. Before the chute came into operation ?—Yes.

31472. That has been intercepted, but discharged rather nearer the mouth of the Lagan than before ?—That is so. (*Mr. Thompson.*) Nearer the city than before.

31473. Whereabouts in the city would that be ? At the foot of High Street, it discharged in the main docks. (*Mr. Kelly.*) In the very heart of the town.

31474. Then do you consider that at the time the chute came into operation the Corporation had fairly well provided the necessary plant and tanks for such population as existed had in 1887, when they undertook the obligation ?—(*Mr. Thompson.*) I think they made an honest attempt then to deal with the sewage of the city as it was at that time.

31475. But in the meantime it had increased, and subsequently, there was an extension of the city boundary, was there not ? Was that before 1894 ?—There was a very considerable extension of the city boundary, but I think what aggravated the evil more than anything else was the 22,000 small houses being supplied with water closets, instead of continuing to use dry ash pits. That increased the volume of sewage immensely ; that commenced in 1899, shortly after the passing of the Act of 1899. In fact, in my own firm we had 120 houses in which we had to make the change to water closets from dry ash bins.

31476. Have you any *data* as to the gradual increase in time of the amount of dry weather flow ?—(*Mr. Kelly.*) Increase in volume ?

31477. Yes, volume now as compared with that of 1887 ?—Taking the rate that was given by Mr. Cutler, the population of 1887 would be about 247,000, and now it is up to 380,000. The provision was originally made for dealing with the former population. They had a settling tank of about 5,000,000 gallons, which meant 10,000,000 gallons they were dealing with per day. That has long since ceased to be sufficient, and the result is that they had to discharge at all times of the tide. This irregular disposal of the sewage has been going on for many years ; it is going on still.

31478. Besides the increase of the population, there is an increase of the amount of sewage per head of population, owing to the substitution of water closets for privies ?—(*Mr. Thompson.*) That is a very important factor.

31479. (*Colonel Harding.*) With regard to an answer you made to a recent question, Mr. Kelly, you spoke of a settling tank ; it was really a storage tank ?—(*Mr. Kelly.*) I should have said a storage tank.

31480. Any matter in it was at once let into the sea ; nothing was removed from the sewage ?—No precipitation.

31481. The whole sewage matter was discharged ?—It was simply a question of deposit ; ponding, and discharging into the tideway.

31482. The object of the tank was simply to store the sewage ?—That is quite right.

31483. So as to ensure this discharge within permitted hours ?—Yes, quite so. (*Mr. Thompson.*) And that is a very important factor, Sir. We hold that, discharged in the proper hours, it would not do nearly so much damage. It is the constant discharge that does the damage.

31484. (*Chairman.*) Will you tell us what exactly are the hours according to the Act ?—They are regulated by the tide, Sir. It is shortly after full tide, so that the receding tide, the ebb tide, will wash away into the sea any sewage mud discharged.

31485. But not throughout the ebb tide ?—(*Mr. Kelly.*) Three-and-a-half hours from the time the tide begins to recede, at the end of which time it stops, and then there are two-and-a-half hours to allow it to get to sea.

31486. To allow it to get to sea ?—Of course, it never really does get to sea ; the currents are too slack.

31487. At this date when the chute came into operation, were you getting any serious pollution through the Connswater River ?—The main sewage disposal of Belfast has not at any time relieved us absolutely of the Connswater River sewage.

31488. But do you think that the quality of the water contributed by the Connswater has been materially improved ?—An effort is now being made to improve the Connswater system. There is a lot of sewage going into the Connswater River that will in the near future be intercepted by a new drainage system the Corporation have under consideration at the present time.

31489. Until recent times then the Connswater has been contributing polluted water to the old mouth of the Lagan ?—It has, Sir, independent sewage matter, to that which finds its way to the Antrim discharge, I mean the discharge on the Antrim side of the Lough.

31490. By the time these outfall works were completed, although they did not provide wholly for the increase of the population as you represent, did you observe, when the chute came into operation, that there was a material improvement in the condition of the Lagan from the Harbour Commissioners' point of view ? I am not speaking now of the foreshore nuisance ?—Oh, yes ; the water was very considerably improved so far as the river was concerned, I mean the river proper, from the Queen's Island up to the town. There is no doubt whatever that a very marked difference in improvement was experienced so far as the river was concerned.

31491. At the date the chute came into operation, to what extent eastward had your navigation channel been deepened ? Did it exist as at the present time ?—We were at the time cutting a new channel. We commenced cutting that new channel in 1885, and the Main Drainage Bill was promoted in 1887. We finished the channel in 1891. It was opened in July of that year. The vessels were, in the meantime, using the old channel, and the water was practically to a very large extent flowing through the old channel. Prior to the final opening, certain portions flowed through the new channel as it was being made. The dredging of the channel was commenced in 1885, and was finished in 1891.

31492. The opening of the new channel pretty nearly coincided with the commencing of the discharge from the chute ?—Practically, Sir.

31493. And did you not find that silting up occurred very fast at first, when the chute was in operation ?—The chute began to silt up from the very first. In 1899, I think it was, the chute was silted up to within about 18 inches of the top ; a 4 feet deep chute.

31494. About what date do you say ?—1899. The chute got completely blocked in the year 1904 at its seaward end, but for years prior to that it was silting up by degrees, and could not withstand the pressure to which it was subjected in order to deal with the volume that had to pass through it. It burst up, broke up in many places, right along the whole line of the chute a mile long. It was a very light structure in the first instance, and frailly put together.

31495. And the chute becoming blocked and imperfect in that way, what was the effect on the discharge of the sewage ?—Well, Sir, the sewage was discharged then at practically all points along the chute on to the slob lands ; and found its way all over those lands. A certain amount was precipitated on to the slob, and a large amount on the beds of our navigable channels. These deposits we had to dredge out at a cost of £13,000 or £14,000.

31496. A great many solids went into the Seal Channel and into the Lagan in that way ?—A large portion came into the Seal Channel.

31497. I suppose when that chute became blocked to an extent leaving only 18 inches of the opening at the end, they did not attempt to pass sewage through it, did they ? Did they have some other outlet from which they could discharge the sewage ?—As a matter of fact, Sir, the sewage was completely blocked at the seaward chute outlet at the end of 1904, and the only openings available were openings made, some voluntarily, and others involuntarily ; the voluntary openings were those which the Corporation made here and there, such openings having, in some cases, areas about double the capacity of the chute. The capacity of the chute is about 64 superficial feet, and the entire sewage came through those openings as they were being made from time to time.

31498. It was all passed into the sea by way of gaps in the chute ; it was not, any of it, let out by a by-pass into the Lagan ?—No ; not directly passed into sea, but then the sewage found its way out before getting through the entire length of the chute which was a mile long. (*Mr. Thompson.*) I think I could explain. The Corporation came to us from time to time, and got liberty to make storm overflows into the docks. These storm overflows would have been right enough if they had been confined to that, but we found sewage matter was coming through these storm overflows, and we were obliged to give them notice to stop them up ; they became just main drains practically into the docks.

31499. Was the result practically they were discharging sewage at all states of the tide ?—(*Mr. Kelly.*) That is so, Sir.

31500. And that lasted for how long ?—It is going on yet, Sir. They have not completed their arrangements for precipitation, but a large amount of sewage sludge is taken to sea now every day. I think they take about six or seven cargoes a week, but after all there is still a large quantity of sewage going through the openings of the chute. However, I expect that will be remedied in a little. I think the Corporation are now doing their best really to get rid of this difficulty.

31501. The result of that has been that a considerable amount of the total sewage—you perhaps cannot say how much, but you would say a large proportion—instead of being delivered at the end of the chute, has been delivered in the course of the chute, either directly or indirectly into the Seal Channel ? Is not that so ?—That is so.

31502. And you think over a series of years it amounted to half the total outfall in that direction ? Can you form any estimate ?—The only estimate we could form would be the approximate quantity of sludge that might be sent from the city in a day, or the quantity of stuff we had to dredge from the river Lagan, at least within the navigable channel, approaches to the city. It is very difficult to determine how much of that would be ordinary silt, normal or natural deposit, and how much sewage, but there was a very large proportion of it sewage.

31503. But did the navigable channel, in the neighbourhood where the Seal Channel adjoins it, become especially prone to silt up ?—At that particular time ?

31504. At that particular part of the channel ?—At that particular part of the channel more than any other part it very much increased, and in some cases the silt was 5 or 6 feet deep.

31505. Then the sewage in the Seal Channel on the ebb ; what course did it take ? Did that pass, most of it, away by the navigation channel, or did it cross the Seal Channel, and so get into the old channel, and go out through the Pool of Garmoyle ? We want particularly to get your views about this ?—From the Seal Channel it crossed the main channel, and got into the Old channel ; some portion of it would get into the Old channel. We had to dredge a very large portion within the Musgrave Channel, a new channel that had been formed some years ago. I could show you that much better on a larger scale map. (*Mr. Thompson.*) I think I would like to say that the incoming tide washed the sewage over all the channels and all the docks.

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31506. We are coming to operation of the flood tide presently, Mr. Thompson. Have you any direct evidence, Mr. Kelly, as to the current crossing the Victoria Channel from the Twin Seal Island ?—(*Mr. Kelly.*) Yes, we have ; crossing from the Seal Channel here right across to the Musgrave channel to your left (*pointing out on map*). That is the old channel to your right. We had noticed that it crossed over from one to the other, right across the Victoria Channel, and that a very large amount of silting up had taken place within about 1,000 or 2,000 feet of the end of the Twin Island.

31507. You put floats into the Seal Channel here, and they have come across here (indicating) ?—That is so.

31508. (*Colonel Harding.*) May I ask about this Musgrave Channel ? It is in the nature of a dock ?—It is not intended to be used as a dock ; there is to be a dock at its southern extremity, it is only looked upon now as an approach to a future dock. It is at present used for fitting out those large vessels built by Messrs. Harland and Wolff. It is intended mainly as an approach to a dock, the construction of which the Harbour Commissioners (as I believe) will very likely take into consideration in a very short time. That triangular piece will all be devoted to a dock. (*Mr. Thompson.*) We have Parliamentary powers to make a dock at the top of the Musgrave Channel, but we have not exercised them yet. We intend to do so at a date in the near future.

31509. (*Chairman.*) There is no land water comes into the Musgrave Channel here at all ?—No, Sir.

31510. (*Mr. Tatton.*) What was the direction of the wind when your floats came across that ?—(*Mr. Kelly.*) Unless I had the notes of the observations here I could not tell you, but we took them under varying conditions of wind. I think myself that the Corporation would be prepared to admit that the sewage goes over there too. They sent down one or two of their officials during the time we were dredging Musgrave Channel to examine the stuff we were raising by dredging. I do not think there is any doubt about it.

31511. (*Chairman.*) You think the last part of the ebb from the Seal Channel was crossing the navigation channel there ?—I do not think very much of it would get into the old channel. A large quantity was, however, driven by the incoming tide into the Musgrave Channel, but I do not think a very large proportion would find its way down to the old channel. The current, you know, is confined, practically, mainly to the new channel.

31512. And it was backed up by the incoming tide ?—That is so.

31513. Then your point comes in, Mr. Thompson, that by the incoming tide it would be spread over a wide area ?—(*Mr. Thompson.*) It was all spread over. In the shipyards we had complaints that in the hot summer weather they were subject to serious injuries by these very offensive smells, in connection with ship-building works where thousands of men were about.

31514. (*Colonel Harding.*) That is here (*indicating on chart*) ?—Workman and Clark's complained most of all (*Mr. Kelly.*) These are slobs that are filled up, but this is the particular place the workmen complain of ; there is a very large deposit on the slob land there. (*Mr. Thompson.*) I might state that an inhabitant of Belfast who was rather troublesome took action against the Harbour Commissioners, in consequence of the nuisance in those docks. We fought it through two Courts, and got it put off, but we felt we were in the wrong, and probably if he had carried the thing right through we would have lost the case. We would have failed in any such action. We were the people primarily to blame for having the nuisance existing in our docks.

31515. (Mr. *Stafford.*) How do you know it was sewage mud in the Musgrave Channel ?—It is very easy to distinguish, even without analysis.

31516. Did you have any analyses made ?—We had analyses made by Sir Charles Cameron, but, even independent of that, there could be no doubt. The poor fellows in the dredger were themselves taken sick occasionally, working in the thick of this thing, and their food was from time to time so tainted that they had to send it off the dredger and were obliged to eat it on the Twin Island at some distance away from the dredger.

31517. Did you make any analyses?—Sir Charles Cameron made two analyses. He made but one visit; I am talking now about the sewage sludge.

31518. (*Chairman.*) Similar to that you had been dredging up in the old navigation channel?—You would find it fully as bad as that, if you were down near where the dredgers were working.

31519. (*Mr. Stafford.*) Could these men or you, Mr. Kelly, distinguish between the smell of the sewage mud and the smell of the *ulva* deposits?—The ordinary person could not; I believe I could. When you stir the *ulva* up, and when you get to that black underlying portion which gives off such a very nasty smell, it is fully as bad as any sewage you could get under your nose.

31520. Do you think that is the sewage or the *ulva* (*offering a vial of fluid to Witness*)*?—That is from the *ulva.*

31521. That is from the *ulva*?—I would imagine it was.

31522. The *ulva* smell has got some peculiar vegetable smell about it?—Well, I do not know.

31523. A smell of vegetable decomposition?—This is something like the smell of the *ulva* when it is stirred up, and I think it is even more offensive than the smell of sewage; but there is no question about it, that there is no *ulva* where the dredging to which I have just referred took place, and where the dredging men got sick.

31524. (*Colonel Harding.*) You are speaking now of the north side of the channel?—Of the Seal Channel entrance and of the time when we were working there.

31525. Of the north side of Victoria Channel?—The north-west side of Victoria Channel immediately north of the West Twin Island.

31526. (*Mr. Stafford.*) Did not your dredgers dredge up *ulva* along those channels?—No, we never dredged any appreciable quantity of *ulva*; it is generally driven on to the banks and deposited there.

31527. No *ulva* at all dredged?—I never heard of any *ulva* being raised by dredging, that is to any noticeable quantity.

31528. There is a considerable amount of pollution, is there not, from the water closets connected with the Harbour?—Well, there are very few connected with the Harbour Commissioners' property, but on the Harbour Estate tenants have used and are using water closets.

31529. That is what I mean?—Messrs. Harland & Wolff's ship-building yard is a case in point.

31530. That is what I mean?—We are powerless in that respect. We admit there is a large quantity of sewage flowing into the tideway from these yards, but we cannot get an easement from the Corporation for an intercepting sewer. Plans were prepared years ago, and we have waited upon the Corporation, but so far we have been unable to get an easement. They had already arranged to give us an easement in Mersey Street, but it appears now, owing to the new arrangements, the re-arrangement of their main drainage system, that they will have to give us an easement in some other direction so that in the meantime we are absolutely powerless. We have no means of disposing of the sewage sent out by Messrs. Harland & Wolff, and Messrs. Workman Clark & Co., Ltd. Messrs. Harland & Wolff send out a great deal, but Messrs. Workman & Clark very little, the latter using the earth closet system.

31531. You state somewhere that there are 10,000 water closets discharging from the Harbour?—There were 10,000 men. (*Mr. Thompson.*) That would be absurd; 10,000 water closets.

31532. 10,000 men?—(*Mr. Kelly.*) The *excreta* from 10,000 men. Yes, we admit that is so, but we have no proper means of disposing of this sewage as we should like to do.

31533. Where is that discharged?—The main portion of it is discharged into Abercorn Basin. That is the Abercorn Basin there. (*Indicating on plan.*) There is a large drain here which we laid for the purpose of draining what we call the Ballymacarrett property. This drain is really under Messrs. Harland & Wolff's Works, inside their own grounds. This firm has without the Commissioners' knowledge or consent sent their sewage into it, and it comes through the Abercorn Basin into the Victoria Channel at this point.

31534. (*Colonel Harding.*) That is into the river?—That is into the river; yes. (*Mr. Thompson*). We have all our arrangements made, I may say, to carry out a drainage scheme for these ship-building works, but we cannot get the outlet from the City Council. We have notified to them that we are ready to carry out the work.

31535. May you not therefore be dredging some of your own sewage?—(*Mr. Kelly.*) Oh, naturally.

31536. (*Mr. Stafford.*) The sewage that you get coming into the Musgrave Channel is the sewage that comes down the Seal Channel?—Yes, but then the bulk of the sewage of Belfast is coming down there.

31537. But surely the great bulk of the sewage of Belfast does not discharge into the Seal Channel?—None of it has got out, until within about scarcely a year ago, through the outlet at that particular point (*indicates place on map*); it has all been sent out here over high lands, flowing in this direction, and in such a way as to get into a basin here; instead of going into the sea near to Whitehouse Roads as it ought to go, it is sent over the slob land at various points along the line of the chute.

31538. But you do not pretend it goes that way at present?—Well, it ought to be sent to sea. The sewage is largely going in that direction.

31539. There is a certain amount of leakage?—There is a certain amount of leakage; the main body of the sewage is, of course, now being taken to sea by sludge steamer.

31540. But the main body of the sewage is discharged at the end of the chute?—If you were at the chute now, you would find that there is no appearance of discharge. There are two openings in the chute for the purpose of repairs, and those are practically constant. As soon as one repair is complete, they have to start at another place so you have a full area, if not double the area of the chute, on the roof of it, while repairing is being carried out from time to time.

31541. Your opinion is that the main body of the sewage of Belfast is now discharging into the Seal Channel?—Except this large quantity of sludge which is taken out by sludge steamer. It is a great relief to the Harbour Commissioners, a very considerable relief indeed, because we have had to dredge from time to time those places where this immense deposit has been sent into the tideway. I might be permitted to say I think, under my Chairman's correction, that the Commissioners are not the only parties who are paying attention to these matters. We are concerned mainly in protecting our interests in the channel and neighbouring slob lands our property.

31542. Your main object is to get the solids out of the sewage?—Except in so far as we have property here; that is the Harbour Commissioners' property boundary. (*Indicating on chart.*) We have slob lands there, and any ratepayer like the gentleman referred to by Mr. Thompson could in all probability make the Harbour Commissioners responsible for sewage deposits lying on their slob property. He can sue the Harbour Commissioners although they have nothing to do with the creation of the nuisance, provided it exists on their property.

31543. But apart from that, your main object is to get the solids out of the sewage?—Yes. (*Mr. Thompson*). But I think the question arises that, supposing you take the solids out of the sewage, will the ammonia that is in the fluids, not continue this *ulva latissima* which is so objectionable. That is a matter for the experts I think.

31544, I want to see how that affects you, and I think Mr, Kelly's answer to that is, that it really does not affect the Harbour Commissioners.

31545. (*Colonel Harding.*) Might I ask Mr. Kelly whether the Harbour Commissioners have found the necessity for their dredging to be reduced since the sludge has been withdrawn from the sewage?—Oh, clearly, Sir.

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* The sample submitted to witness contained debris from the filters of the London Water Supply mixed with London supply.

31546. You have noted a distinct improvement ?—We are deepening our river now, I mean the Victoria Channel, for the purpose of providing sufficient water for these large vessels which are now being built by Messrs. Harland & Wolff. We are deepening it by an extra 3 feet, so we really could not tell so well now as we might do under ordinary circumstances.

31547. What is your impression ?—My impression is that it is a very great relief to us.

31548 (*Mr. Tatton.*) Do you dredge in Victoria Channel, this part of the river at all ?—Oh, yes, we dredge right up to the bridge.

31549. What result do you get here; do you find sewage sludge there ?—Oh, yes, All the sludge we get there is of a sewage character. There are sewers still discharging into the River Lagan. The whole sewage of Belfast is not going to the main outfall works; some of the old sewers have not really been intercepted yet. There is a large volume of sewage matter comes down through a sewer here.

31550. (*Colonel Harding.*) There is a great deal of storm overflow ?—There is a large amount of storm overflow.

31551. (*Chairman.*) And you are continually dredging in the Musgrave Channel ?—Yes; this channel is a *cul de sac.* We shall require to be constantly dredging this channel, more or less.

31552. And the dredgings you get in the Musgrave Channel; what kind of dredgings were they ?—Well, we found there mainly near the entrance a layer of about 4 to 5 feet in depth of sewage, pure crude sewage; nothing in the shape of the ordinary natural deposit of silt, that we know how to compare, one with the other. (*Mr. Thompson.*) I think with regard to dredging I would like to say that, before launching one of these very large steamers that are built in the ship-building yards of Messrs. Harland & Wolff we have to send round our dredgers, and dredge out to the legal depth of the channel, to make way for launching; so that shows that these solids are constantly accumulating in the docks and in the harbour. (*Mr. Kelly.*) There is not a large amount of coast erosion to contend with, it is very slight in Belfast. and the amount of material brought down by freshes of the River Lagan is not very much. So that really what we have to deal with principally are deposits due to waste products in connection with the city itself. We are singularly free from a large amount of erosion, so far as our coast is concerned.

31553. You think the amount of detritus from the banks, if the sewage were taken away, would give you very little trouble ?—Very little trouble; that is an experience disclosed by a Consulting Engineer's Report, in 1832 or 1833.

31554. Now, I wanted to ask you, when the chute was intact and was for a time discharging raw unsettled sewage from its mouth, did you find any ill results from that discharge, as far as your navigation channel was concerned from the Eastward ?—It never was perfect; it always leaked from the very first. Within a month or two of being put into use it commenced to leak.

31555. But do you find any objectionable result from what is now discharged from the mouth of the chute ?—Oh, there is none discharging at the present time from the mouth of the chute. The mouth of the chute is practically closed now; the openings come in intermediate portions of the chute, and afford outlets for the sewage which consequently does not find its way down the chute to the outlet.

31556. What direction do you think suspended matter in sewage, although the sewage was discharged in large volume from the mouth of the chute, would take, if limited to the first three and a half hours of the ebb ? Would it go straight out to sea ?—I do not think it could ever find its way out to sea judging from my own observations taken of the tidal currents. I fancy I might almost endorse those of Mr. Cutler, the City Surveyor, because they were, perhaps, more carefully taken and more elaborately taken than mine. I think the measures of the currents to be got from the City Surveyor ought to be taken as correct. All that goes to show that the tide is very sluggish, and it would be almost impossible to expect that the sewage would be taken out to sea under any conditions.

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31557. Do you think it would tend towards the County Down shore ?—I think it would have a tendency in that direction, Sir.

31558. (*Mr. Tatton.*) It has been suggested as one remedy that some of the slobs lands, at any rate the worst of them, should be enclosed with a sea wall and reclaimed. Has your Board considered that point, and would they have any objection to it ?—(*Mr. Thompson.*) We have had it under consideration; it would be a very expensive operation.

31559. But apart from the question of cost ?—(*Mr. Thompson.*) I have no doubt that would be an improvement apart from the question of cost, but then the Holywood people would suffer, because the whole trouble would be on them if we enclosed the slob lands from Belfast to Kinnegar. My impression is, if you want to know what I think would be a remedy, that there should be a large main drainage scheme carried to Black Head and dropped into deep water, where it could not give any trouble. I think that is an effectual cure.

31560. (*Chairman.*) Where is the Black Head ?

31561. (*Colonel Harding.*) A distance of about 8 miles ?—It is far more than that; it is 13 miles.

31562. Would you have any objection from the point of view of the Port; would it do any harm to the channel if those lands were reclaimed ?—I think it would do no serious injury to us.

31563. Do you agree to that ?—(*Mr. Kelly.*) I think it would be injurious to the channel, but it would come in the long run to a question of pounds, shillings and pence; I mean the extra cost of dredging the channel. If you reclaim a certain amount of land, you deprive the channel of a certain amount of the backwater necessary to create a scour. But the Commissioners will, no doubt, from time to time themselves have occasion, as they have done recently, to reclaim land for commercial purposes, for harbour purposes; and then, if they do so, they must make up their minds that, by this reclamation, they must pay a little more for the dredging annually, so it is a question entirely of pounds, shillings and pence with them. I think it would be a great matter if you could reclaim the whole of the slob on both sides, but then the Commissioners would have to suffer from the effects of such reclamation, unless there was some arrangement come to whereby the parties who reclaimed would keep the Commissioners safe with regard to their annual expenditure. I understand, from Mr. Cutler, that they have modified their views with regard to the proposed reclamation. Instead of going to both sides of the Lough, they would be content simply to reclaim one side, and only to the extent of 750 acres.

31564. (*Chairman.*) The County Down side ?—The County Down side. But then there is a very great drawback in this. There is the County Down reclamation shown in pink, and the yellowish or brownish colour there, is a large quantity of unreclaimed land that would be left unreclaimed, and the tendency would be when you shut out the matter held in suspension in the tidal water simply to precipitate it there (*Points out the place on the Map*), and the evil would be increased or practically repeated a little further north. The great trouble, I think, at the present time is at a place near Cultra, where there is an immense amount of *ulva* swept in from time to time. There, there would be a very large area left unreclaimed; I have got the figures here. If you reclaim the portion that was talked about first by the City Corporation, it would represent 828 acres, after reclaiming which there will still be 511 acres unreclaimed. That is all that part of brownish and yellowish colour, buff colour. That would represent down to this point, 511 acres (*Indicating*). You can see that it would extend almost to Gray Point on the County Down side; there is a foreshore nearly to Gray Point. Of course, the coast is somewhat rocky on that part of the County Down side.

31565. And you think that with a perfectly intact and improved chute, and all the sewage up to three times the dry weather flow discharged here, you would get the nuisance there ?—I think a portion of it might come across there. This is, of course, a matter for speculation.

31566. Under present conditions, if the Tillysburn area were enclosed and the foreshore beyond Kinnegar

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left bare—under present conditions of pollution of the Seal Channel—sewage would be deposited on that foreshore to the Eastward?—I speak of the reclamation as being a very good idea for getting rid of the nuisance if it could be done thoroughly, but a partial reclamation, would, I fear, only be a partial remedy. (*Mr. Thompson.*) I think reclamation would be an important improvement to the City of Belfast, but our neighbours at Holywood and on the Antrim side would suffer by such a reclamation.

31567. (*Mr. Tatton.*) With regard to the scour, Mr. Kelly, does the tide assist you materially with your dredgings; I mean to say is the amount of material that you have to dredge reduced?—(*Mr. Kelly.*) Oh, there can be no doubt about that; there is no doubt whatever about the value of the tide as a scouring auxiliary.

31568. What is the velocity of the tide; the maximum? —It has worked out about ¾ of a knot in the main channel.

31569. What would that move, a velocity of ¾ of a knot?—I have not gone into these figures recently. (*Mr. Thompson.*) The rise of the tide is about 8 or 9 feet.

31570. But the point is, the velocity?—(*Mr. Kelly.*) We have ascertained the value of the tidal scour from the experience we have had of the dredging of the channel opened in 1891; we know it required very little dredging until this large quantity of sewage silted up in the channel bed. Of course, when we dredge, we have to take into account the future side slope of the channel; which will after dredging assume what we call the natural slope, and which slope is eaten away from time to time; we assume the natural slope about 7 to 1. It lies something like that. (*Indicating.*) We dredge right into the bottom of our slope, but this silts into the channel from time to time. That is what I call natural, in contradistinction to sewage deposit, and that natural deposit will go on till we get to this angle of 1 in 7. That is what we have found on the foreshores of the Lough, generally speaking, to be the natural slope, so that that deposit we will have to take away from time to time; and we can account for the ordinary silt really as representing these side slopes, dropping in, this is the normal deposit which we have to dredge from time to time.

31571. But I suppose that would not be effected by any slight change in the velocity of the current, would it?—Any slight change in the velocity of the current?

31572. I mean, suppose the current were reduced by the amount of water flowing over the slob land?—It is altogether a matter of speculation as to the extent to which that will be effected. An immense quantity of water would be shut out from the slob lands, the backwater; and all those engineers who have hitherto reported upon the subject have strenuously protested against reclamation, for the simple reason that it would deprive the channel of an immense quantity of backwater which is invaluable for scouring purposes. The last period of the receding tide is the time the scour of the backwater does its best work, and if you get rid of that water——

31573. The last portion of the ebb?—The last portion, yes.

31574. The last portion of the water is off the slob lands altogether?—It is when that portion of the receding tide to which I refer is rushing off the slob lands that the scour is augmented.

31575. It is cleared off the slob lands; the slob lands are then bare?—They are getting bare. The scour is most effective when the water is in the act of leaving the slob lands bare.

31576. (*Chairman.*) It is running off them directly towards the channel?—It is running on towards the channel. You can see, if you look at that chart, that there is a pool, called the Pool of Garmoyle. That is the only way to account for the existence of that pool; you find deeper water there than you find anywhere else round it. You find deeper water in the Whitehouse Roads than in its immediate vicinity. Before the straight channel was cut, there was a bar right across there. This is not now, as it originally was, the ordinary navigable approach. At the present time large vessels lie there for shelter. But that Pool of Garmoyle was undoubtedly formed by the rushing in of the backwater here, and here, and hollowing out the sea bed, the same thing would occur there (*pointing out on chart*); giving us a pool there, which is deeper than it is out there. Now this Pool has silted up very considerably in recent years, and it is now practically a large cesspool for sewage sludge.

31577. Why is that; what is the reason for that?—Because the scour is diverted into the new channel. It used to go here. This was the old channel. The scouring helped to keep that channel open before the new cut was made. We had occasionally to dredge at this part, not, however, very often.

31578. (*Chairman.*) Would you attribute any of it to sewage solids coming from the chute?—Oh yes, Sir. The chute ends about there (*Indicating*) and there is a large quantity of this sewage sludge deposited to the northward of the chute outlet. There is no other way to account for the silting up there. As I said before, the cost erosion is very slight.

31579. (*Mr. Tatton.*) Does the land water assist you through your channel?—Oh yes, it is a very valuable aid to us, but there is very little backwater comparatively. Unfortunately, the Lagan is not a very big river, and we have hitherto invariably and consistently endeavoured to prevent reclamation up there. We cannot count very much on the Lagan water as an auxiliary scouring medium. The combined backwater from that river and the backwater from the slob lands have, however, up to the present, been found to be most effective in inducing the scour which keeps open our navigable channel approach.

31580. Would it not assist you to have the Lagan water more constantly. Now it spreads all over the slob lands. Would it not assist you to raise that land so as to concentrate the land water into your channel; would it not assist the scour?—If you got plenty of backwater and were able to confine it between two straight walls or training walls, undoubtedly it would help the scour there. The backwater rushing off as it does now, into our straight channel from both sides helps very considerably to clear the channel. The fact really is that we do not require to dredge except to the extent necessary to carry away the material of the side slopes that fall in, I mean the lower portions of the slopes on both sides of the channel, and after a time, if the sewage were absent, we would require very little dredging in that channel.

31581. It is not the actual fall of the tide; suppose you had slack water there entirely, with the tide rising and falling, would not that rise and fall of the tide of itself work that stuff down that you spoke of on the slope?—Oh, no; it is the current really, the undercurrent, that eats away the sides of those slopes. The channel is pretty deep. The bed is 32 feet below high water of spring tides; and the deeper you go the less effect the scour would have on it. There would still be a certain amount of scour; there would not be so much if the slob lands were reclaimed. The tidal water would of course rise up the River Lagan. I daresay we would still have a certain amount of scour. (*Mr. Thompson.*) But we would not have the full scour Mr. Kelly refers to. (*Mr. Kelly.*) If you see your way to the reclamation of the lands, I do not anticipate very much difficulty about the harbour. The reclamation of 750 acres of land there (*indicates position on Map*), supposing that all parties were agreed to it, would become a commercial question rather than an engineering question. The Commissioners might say: "Well, we do not object to this being carried out, but we hope you will indemnify us with regard to the extra cost of our dredging."

31582. You do not mind?—It is really more a commercial question than anything else. If we can keep the channel open (that is what immediately concerns the Commissioners) it would be a great advantage, there is no question about it, an immense advantage, to have those lands reclaimed.

31583. (*Chairman.*) There is one other point. You say the most effective remedy, and the most practicable would be the treatment of the sewage at the Main Drainage Works in such a manner as that the highest possible and reasonable standard of purification of the effluent could be attained before discharging it into the tideway. Are you contemplating their giving up the chute on the condition that that amount of purification was achieved, and are you thinking that purification to that extent, under the conditions of discharge similar to what takes place in Seal Channel now, would prevent the nourishment of the *ulva* on the Tillysburn Banks?—I am not prepared to say that; that is a matter for the experts, chemical and bacteriological, but I think that perhaps the Commissioners would be satisfied if the solids were eliminated, and that a reasonable amount of purification was provided for. As to a reasonable amount, that amount might possibly be about 80 per cent.

31584. It would satisfy the Harbour Commissioners as Harbour Commissioners, but you would say nothing as to its effect upon the nuisance of the *ulva* growing ?—I am not prepared to say that the growth of the *ulva* would be arrested by the purification of the effluent to the extent suggested by me.

31585. We have had evidence that it would not perhaps fail to nourish the *ulva* in very much the same way as the present sewage does now ?—That is a matter for Professor Letts and gentlemen of his particular profession, rather than for an engineer. I have heard it suggested that you cannot ultimately purify to such an extent that you will have no *ulva*. I remember when I was living in the locality of Sydenham, about 1869 or 1870, seeing the *ulva* growing on the banks there. The *ulva* was not then growing to any appreciable extent at Sydenham. In the vicinity of Victoria Park it was growing in shallows, pools that were cut out by the lighter men who were excavating sand on the foreshore for building purposes.

31586. Was it growing luxuriantly there ?—Not luxuriantly.

31587. (*Colonel Harding.*) In the few questions that I want to ask you, Mr. Kelly, I want to divide the past and the future. First in regard to the past; the fact that the Corporation of Belfast have not been able efficiently to carry out what they intended to do, when they opened their scheme in 1893, is the cause, is it not, of nearly all the evil ? What I mean is this, that the Corporation of Belfast proposed in carrying out that scheme to store their sewage so as to secure that it would only be discharged during the first three-and-a-half hours of the ebb, and that it should be discharged in deep water at Whitehouse Roads ?—That is so.

31588. The trouble that has arisen has arisen largely through the failure to carry out what they proposed to do ?—Largely.

31589. Instead of delivering their sewage into the Whitehouse Roads they have, in fact, delivered the great bulk of it, you suggest at times the whole of it, over the banks which are drained by the Seal Channel ?—That is to say over the West Bank. Yes.

31590. Then you state, and no doubt truly, that that has led to the settlement upon those banks, and possibly in the timber ponds and the adjacement enclosures, of a large amount of sewage solids ?—Yes, that is my point.

31591. Now, an interesting point which I want to question you upon is, how far it was likely that those sewage solids, which undoubtedly would settle there, were carried across to the South Shore and to the Tillysburn Banks ?—I could not answer the question.

31592. May I ask you this; you told us just now that the current, apart from the Victoria Channel, was very slow and it might be considered to be about three-quarters of a knot per hour ?—In some cases less, but in the Victoria Channel, it would be about three-quarters of a knot per hour; in the Whitehouse Roads it would be less.

31593. What would it be in the Seal Channel, not at high water, but what would it be over the Seal Channel at the time of the early ebb ?—There would at certain periods of the tide be a run in the Seal Channel of four knots. Sometimes there is a very heavy current at the mouth of this Channel.

31594. That is when the water is low ?—That is so. Have you seen that ?

31595. Oh, yes. But what would it be at the beginning of the ebb ?—Well, I have not got particulars just now as to the strength of the current at the first of the ebb.

31596. But at the beginning of the ebb it would be exceedingly slow ?—Very slight comparatively.

31597. Not more than half a knot ?—Oh, not that much at the beginning of the ebb.

31598. Have you any personal experience of the sedimentation which takes place in a slow current of that kind, where sewage passes along the channel ?—No, I have not taken observations with that object in view.

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31599. But you probably would be prepared to find, would you not, that sewage passing along a channel at that very slow rate, would rapidly deposit its heavier solids ?—Certainly.

31600. Then one would expect that the heavier solids certainly would be settled on the slob lands to the north of the Victoria Channel ?—That is so; that is exactly what we found.

31601. Now, I am interested to find out how far you think that the lighter suspended matter could get across the Victoria Channel and the Old Channel to the south shore of the Tillysburn slob land ?—That is another question that I would rather not answer, because it is altogether a matter of speculation.

31602. Would you venture upon an opinion, that such suspended matters that did get across there, would be the lighter suspended matters ?—Well, I should say so, unless it were carried away in the stronger run of the tide along the Main Channel. But, as you say, if there is any slack water at all, the heavier matter would of course be precipitated before the other. I am not prepared to say definitely whether or not sewage matter has been carried over there at all. I say the current observations have shown that the tide has been ebbing in that direction, and flowing in that direction; the current floats have shown that the flow of the water has been in the direction of the East Bank from time to time.

31603. (*Chairman.*) You do not think that your dredgings in the Musgrave Channel rather suggest that periodically matter has been carried over there ?—Oh, yes, there is no doubt about that.

31604. You do not think it has all come down the Connswater, do you ?—No, a very small quantity appears to have come down the Connswater. Those portions of the Musgrave Channel in which the deposits were mainly in evidence were at and near to the junction of the latter channel with the Victoria Channel.

31605. That leads me to ask about this. Unquestionably large deposits of black mud one finds on the south shore, and especially on the Tillysburn Banks. What do they consist of ? Are they mainly decaying vegetable matter disintegrated growth of the weed, for instance, or are they, do you think, to a large extent direct sewage deposit ?—That is a matter again for the expert the chemical expert. I have not devoted any especial attention to the subject.

31606. Not wholly; you have expressed yourself an opinion that the heavier solids would, in the circumstances of the very slow flow, deposit mainly on the north side of the Victoria Channel ?—Yes.

31607. (*Colonel Harding.*) You expressed the opinion just now that the somewhat greater speed of flow of that channel would tend, at all events during the ebb, to carry these lighter suspended matters towards the sea ?—Yes, it might, but I do not want to have it understood that I suggest for a moment that the sewage which is lying over these banks, the east banks, has been carried over from the other side.

31608. You do not suggest it ?—I do not say that they do. I do not say where they came from; they might have been brought back from the Whitehouse Roads after having been discharged at the proper point of discharge, and might subsequently have been deposited on the bank, because the current is so sluggish that the incoming tide might meet it before it found its way further than the Whitehouse Roads, and might bring it back, I think it would meet slack water again, and might eventually be precipitated upon the slob lands.

31609. Let me pass to another point, the growth of *ulva* on the Tillysburn Banks is very extensive, is it not ?—That is so.

31610. I think your predecessor on the Harbour Board, the Engineer, Mr. Giles, spoke of that as the nursery of the *ulva* ?—I do not know that he could say that Tillysburn was the nursery especially of the *ulva*; certainly there is *ulva* growing there.

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31611. I think he did, in fact, speak of it as the nursery of the *ulva ?*—Doubtless, but I saw on one occasion at Cultra a heap of *ulva* 3 feet high. That gathered there in one night.

31612. That was drifted *ulva ?*—Drifted *ulva*, yes.

31613. But on the Tillysburn Banks you have growing *ulva* which is either naturally rooted or is artificially attached by the mussels ?—That is so, but that would not account for such an immense quantity as I saw on the occasion referred to in Cooper's Bay. It must have drifted from other parts of the Lough, possibly some from Tillysburn.

31614. That may be, but the point I wanted to get from you was that a large quantity of *ulva* does develop there on the Tillysburn Banks ?—That is so.

31615. It would be difficult, of course, to form any estimate of its mass, but it would amount to thousands of tons ?—Well, I would not like to say; I cannot say what quantity there would be. I have not gone into the question of the quantity. The Holywood people that are coming before you to-day will doubtless give you full information on this point.

31616. Are they likely to have more information than you, the Engineer of the Harbour ?—The quantity removed ?

31617. That is not what I mean. The point I wanted to get at from you is that this immense growth would naturally produce a large amount of decayed vegetable matter ?—Yes.

31618. Now we are told that in the winter time the green *ulva* disappears; you probably know better than I do, is that so ?—That is so.

31619. Then we are also told that a large quantity of the decayed, the black *ulva* on these banks is washed away. A recent experiment in which a small area was cleared of mussels showed that in the course of a few weeks the mud which had been there to a considerable depth had been washed away; there was nothing to hold it together, and bare sand was left ?—That is accounted for by high winds; occasional storms. I have known the sand on Holywood Bank to shift about 2 or 3 feet in one night's gale.

31620. You would agree that a very large quantity of vegetable detritus is washed by these banks ?—I should say so.

31621. And that would tend to fill up your channels in the same way as the solid matter from sewage ?—Yes, likely. It is offensive matter such as I have referred to, and it is matter created, I take it, as the result of sewage deposits.

31622. Well, if the effect of reclamation was to keep out all this matter from coming down into your channels would not the keeping out of this matter to be scoured out compensate for the reduction of the quantity of water that produced the scour ?—Well, hardly. We have a sort of intercepting channel here. (*Indicates position of old channel on chart.*) Now that old channel is practically useless, we do not care if it were closed to-morrow; it would be all the better for us if it were. Before the straight channel was formed between 1885 and 1891 all the vessels passed through this old channel. This matter that you refer to, Colonel Harding, would now be deposited really in the old channel before finding its way to our new channel.

31623. Probably ?—Well, I think, very probably so. If you take it, that the old channel intercepts this floating matter it is really a trap to prevent it getting into the Victoria Channel; that would discount the other question a bit.

31624. (*Chairman.*) In so far as it was brought down by the tide into your old channel would it not pass out of your channel again with the ebb ?—There is very little scour, very little current here now, Sir (I mean in the old channel); the main current is through the new channel.

31625. Even on the last of the ebb there is not much current there ?—Even at the best, why, even our straight channel has very little more than two-thirds of a knot.

31626. (*Colonel Harding.*) But anyway, it is a point to be kept in view, that although the scour might be reduced by such reclamation, so also the matter to be scoured out would be reduced ?—Clearly. Yes, there is something in that; possibly some of it would find its way into our new straight channel.

31627. In regard to this point of reclamation, it is a very proper thing to consider, although there is not a serious evil on those portions of the slob lands from Kinnegar Point to Cultra. If this reclamation took place it is conceivable that the evil complained of at Tillysburn might recur on these slob lands ?—Yes, unfortunately, I am afraid that it might.

31628. But at least the authorities would begin by leaving ground which is fairly clear at present from the growth and attachment of *ulva ?*—Yes, your point is that the *ulva* does not grow so much on the Holywood Bank, and the reason of that is that it is a sand bank shifting constantly; nearly every gale of wind causes this bank to change 2 or 3 feet. If you were to take soundings to-night, and there was a gale of wind during the night, you might find a different of 2 or 3 feet in your soundings to-morrow. The sand is shifted backward and forward periodically though regularly. In all probability there would not be anything like so much growth on any of these banks as there would be on banks where the surface does not change so much.

31629. Do you not think these conditions would continue after reclamation ?—The chances are they would, not exactly in the same way as if the water was flowing from this bank into the tideway over that *ulva* bank.

31630. Starting off with a clean shore it would be far less difficult to deal with the growth of *ulva* that might arise there than it is now on the Tillysburn area, where it is a settled growth, and where you have enormous mussel beds ?—Yes. There is a considerable growth there. It would be a great advantage to get rid of the *ulva* which grows on the slob at this place.

31631. (*Chairman.*) And the effect of settlement of the sewage would also reach to the sea. You would not have so much suspended matter capable of forming mud or of nourishing weed coming down with the ebb, at least, that is the hypothesis ?—Well, there will be very little solid sewage discharged into the tideway when you get this precipitation system completed, and then the question will arise as to whether you will be able to purify up to the extent requisite to prevent the growth of the *ulva*, and if you cannot effect this unless you reclaim the slobIands, I think it would be impossible to get rid of the *ulva* difficulty entirely.

31632. (*Colonel Harding.*) So far as the reclamation proposed on the South side is concerned, you and your Board are probably satisfied that that would, when carried out, remove the larger part of the area upon which the *ulva* now grows ?—Yes, it would.

31633. And therefore that such reclamation would immediately bring about a very important improvement ?—Oh, it would at once, most certainly, but, of course, it would take some time to effect this improvement. A considerable period must elapse before you could recclaim the land. Suppose it were decided to carry out a reclamation scheme, you would require in the first place to go for a Bill, and you could not have that Bill ratified until next year, and then there would be the time occupied in carrying out the works.

31634. One quite understands that, but, as a fact, you anticipate that that would be the result ?—Well, yes. I might here state that The Belfast Harbour Commissioners had at one time fixed by one of the consulting engineers, who had reported on the question of a suggested reclamation of slob lands, a definite limit to future reclamation, but the Commissioners have thought it necessary to go beyond that limit and to reclaim land up to the north end of the East Twin Island. In order to complete the Musgrave Channel on the east side, there can be no doubt that we shall have to reclaim land there, too, and the chances are that the Commissioners might favourably consider a scheme proposed by the Corporation, on the lines suggested by the Health Commission in the year 1907, that is to reclaim a tract of land opposite Sydenham down to the city boundary near to Tillysburn, and that reclamation would account for about 300 or 400 acres of slob lands in question at all events.

31635. You quite see that the reclamation would have important utility, quite apart from the reduction of the *ulva* trouble, that the reclamation might be of very great value, not only to the Corporation in obtaining land, but to the Harbour Commissioners themselves?—Well, I think to some extent it would, from the point you have raised.

31636. Then it is largely a matter of conference between the parties which existed?—Altogether, I should say.

31637. To settle these details?—But even if the Harbour Commissoners and the Corporation were to arrange between themselves you would still have the owners of the foreshore there, and I think you would find the Holywood people particularly would be very difficult to settle with. There are so far as I know, only two or three owners of that part of the slob lands coloured pink on the map. The latest idea of the Corporation is, I should state, not to reclaim so much land as they had originally intended; now, instead of 830 they only speak of 750 acres.

31638. To Kinnegar Point?—To Kinnegar Point, but bringing back, more inland, the line of reclamation. The line is shown on this plan. This area only represents a few owners of property. Colonel McCance, Mr. Harrison, and Sir Thomas McClure's representatives, in all probably, three property owners. There are further property owners further north, and the township of Holywood would probably have to be dealt with.

31639. On the other hand, these owners have severance now from the shore by the railway bank, and in addition they have the serious *ulva* nuisance about which they have been complaining for many years very much; they would be relieved by this work?—Yes; the people most relieved would be the owners of valuable property in the locality, Mr. Harrison, Colonel McCance, and the representatives of the McClure Estate, these would be the people more interested than anybody else; there are not many small houses in the neighbourhood.

31640. These people would be relieved?—They would undoubtedly be relieved.

31641. You do not see any difficulty, assuming the Belfast Harbour Board and the Corporation agree, you do not see any serious difficulties on the part of the riparian owners?—No; I think not, at least so far as the riparian owners down to that point are concerned (*indicating*), but beyond that I am afraid you have rather a tough problem to tackle.

31642. No doubt there would be difficulties. Now, with regard to the future, I understood you to say that the withdrawal of 180 tons of sludge, that is the figure given in tons yesterday by Mr. Cutler as the average throughout a considerable period, the withdrawal of 180 tons of sludge per day from the sewage is already showing itself in improved conditions so far as your Board is concerned?—Oh! clearly.

31643. If, in addition to such a withdrawal of the mass of the suspended matter from the sewage, the sewage were so stored as to have its discharge strictly limited to the first three and a half hours of the ebb, and if by the construction of a new conduit, the discharge of the sewage were ensured to be in the Whitehouse Roads, do you foresee, under those conditions, that much difficulty would arise to your Board in the future?—There would be no difficulty at all with the Board so far as I can at present foresee.

31644. You would be satisfied as a Board?—The Act of Parliament entitles the Corporation to deal with the sewage in the manner pointed out by you, the Act of 1887, so the Commissioners, whether they like it or not, have, I presume, no alternative.

31645. So far as you are concerned, that would satisfy your Board?—Clearly, Sir. (*Mr. Thompson.*) I do not think the sewage matter should be delivered in the Whitehouse Roads; it is too near the city.

31646. That would be through the new chute?—I do not care what chute, to deliver sewage matter in the Whitehouse Roads is too near the City of Belfast.

31647. You must understand it would not discharge the whole of the sewage matter, because at the present time 180 tons of sludge has already been withdrawn from it?—A very important improvement, no doubt.

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31648. It would discharge, no doubt, a considerable amount of the dissolved impurities and some suspended impurities, but the conditions would be vastly improved?—No doubt; but the question is how far the ammonia and the other impurities would further the growth of the *ulva latissima* that we find so troublesome. Dr. Letts will be better able to give an opinion on that.

31649. Is that a matter very much for your Harbour Board?—Yes, if it increases the nuisance to the citizens of Belfast; we are the custodians of the harbour.

31650. But scarcely as Harbour Commissioners?—We are trustees for the harbour estate, we are responsible for the docks and the harbour being kept in proper order. If you adopt an extensive system of reclamation, I do not think the Harbour Commissioners would stand in your way; I think they would assist you and further you rather than hinder you. I think the injury would not be serious, through the want of the scour that Mr. Kelly has spoken of. The difficulty is at deep water. Of course, Mr. Kelly is an engineer, he speaks from an engineering point of view, but I think it would be of importance to us if we had deep water all the way up the channel and the reclamation on both sides. (*Mr. Kelly.*) My impression is clearly that it will be a commercial question altogether. And besides there is another point about this business that it should be carried on tentatively, and as the work is going on we could discover from time to time what effect, whether injurious or otherwise, it would have on the scour of the channel.

31651. What do you quite mean by "tentatively"? If you were to subdivide this reclamation from the Musgrave Channel to Kinnegar Point into several channels, it would add greatly to its cost?—Well, Mr. Cutler proposes to divide the reclamation into at least two sections.

31652. That means cross walls?—Yes; as a matter of fact, he must do that in order to keep the Tillysburn Channel open. The owners have a right to water passage there. If you reclaim on the lines proposed you would have to keep this tributary stream open. A certain amount of land would be reclaimed by one of these divisions, and we should then see the actual effect produced by the reclamation. This would determine the question and place it beyond the region of mere speculation. I think it would be a matter that could be easily arranged between the two bodies.

31653. When you suggest it should be done tentatively, you would say, in the first instance, it should not be done beyond Tillysburn?—It should not be done beyond Tillysburn, and if carried out to this extent only we should be able at the end of a year or so to form a fair idea of the effect of the reclamation by very careful and constant observation.

31654. Do you not think that by conferences between the Corporation of Belfast and the Harbour Board a great deal of the delay and difficulty relating to areas would be done away with?—I do, I think it is an absolute necessity that the consent of the Harbour Commissioners should be obtained before such a reclamation could be effected.

31655. Both parties having a conference with a desire to do this thing would find a short way to it?—My impression is—my Chairman is here and perhaps he will allow me to say so—that the Commissioners are in sympathy with the Corporation in their difficulty, and I think they are prepared to facilitate them in any way that they can. The council themselves are an independent trust, but I think they would have the support very largely of the Harbour Commissioners in the carrying out of any reasonable scheme which they might put forward.

31656. And both parties are elected by the same electorate?—Not the same franchise.

31657. Very nearly?—Oh! not nearly the same. (*Mr. Thompson.*) A very important difference. (*Mr. Kelly.*) One is £10, the other £20 franchise. (*Mr. Thompson.*) The shipowners have an interest. We sympathise with each other and assist each other in every possible way. We would put no difficulty in the way of the improvement if we were satisfied it was an improvement and likely to lead to permanent results.

31658. As to carrying out its requirements in the limited form you have referred to, as an engineer would

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you give us any idea how long it would take to construct such a bank from the Musgrave Channel to the Tillysburn?—(*Mr Kelly.*) I did report on this to our Commissioners some time ago, but, at the time, I had in view Mr. Cutler's statement that he could only afford to give 80,000 cubic yards of stuff a year of town refuse, but I have recently heard from Mr. Cutler that he would not confine himself to that output, but that he would open up some ground on the Holywood Hills, and run the stuff down by aerial tramway. This I only heard last night, had I known earlier I might have had some figures with me. I cannot therefore make any statement as to the question of time, but Mr. Cutler has doubtless told you what length of time would be required to carry out the work, and he may be correct.

31659. Mr. Cutler's suggestion for the making of the bank at Kinnegar was a period of two years?—I have gone into very careful calculations, and to make the banks on both sides of the channel would take fifteen years, at the rate of 80,000 cubic yards a year. The resources, of course, are now broadened, and as Mr. Cutler states that, independent of the ordinary supplies from the city, he would procure the necessary materials to form the embankments from the high lands eastward of the Holywood Road, he might possibly be able to carry out the works within the time stated.

31660. He might?—He might. I would not say that he could not do this work in the time stated.

31661. So far as the engineering work is concerned you think it might be done in two years?—I will not say so, it might however be done in that time.

31662. It might be done?—It might be done. A good deal depends on the money you spend, the number of hands you employ, and if they work night and day. It might easily be five years, but if they divide the operations into several sections, and are not afraid of spending money, it could be done in much less time.

31663. (*Mr. Stafford.*) You merely propose to put the bank there, not to fill it in?—That is the entire proposal, because the filling of it in would take centuries at the rate of 80,000 cubic yards per annum; it would be an enormous thing to fill in all this ground.

31664. You agree it would not be necessary to fill in?—It would not. You would, of course, require to drain the reclaimed land in order to avoid causing as great a nuisance as that which now exists, reclamation banks would be all that would be necessary in the first instance, the filling up of the ground inside following as the demand for made up ground presented itself. I do not know what use you could make of the land. It would let for pasturage.

31665. It would be very valuable land afterwards, would it not, after it was reclaimed?—Well, not until it was made up; it would not be valuable at that low level for anything except grazing.

31666. (*Colonel Harding.*) There are large vegetable deposits there?—Well, yes, there are. There would, of course, be an annual expenditure for drainage to be taken into account.

31667. Suppose the reclamation was made, would not that area be useful for you for depositing dredged matter?—Well, I do not know. That is not a question I should like to answer off-hand.

31668. Would not that help to fill up?—Yes, but I want to qualify the answer by saying that we are disposing of our dredgings now very much cheaper than we could dispose of them in the manner suggested. We can send dredgings to sea for 4½d. or 5d. a ton. It costs more than double that to send them inland. Unless we were making up ground specially for harbour purposes we should send all our dredgings to sea. It would not pay to fill up ground which had been banked by the Corporation unless we required the land for commercial purposes. You would not get more than £2 or £3 an acre per annum for the ground for pasturage purposes.

31669. But you could use your dredgings for filling up?—We could, if it paid us to reclaim land for commercial purposes.

31670. It is conceivable that it would pay you extremely well if you could obtain some land in that way for your harbour purposes?—Some portions have paid near the

31671. (*Mr. Stafford.*) It would be very valuable land, for the Commissioners?—That is so, say, cityward of the Twin Islands.

31672. (*Colonel Harding.*) My opinion is that when this land is made the Harbour Board and the Corporation of Belfast will begin to appreciate how valuable this enclosed space will be to them?—(*Mr. Thompson.*) If close to the city or the harbour it would be valuable, but the bulk of the slob land going down to Cultra would not be worth more than £2 an acre.

31673. Some of it is near the city?—(*Mr. Kelly.*) Oh yes; the part I refer to is up to Sydenham, and in the direction of the Twin Island; I can show it to you on this chart. You remember the place, Colonel Harding, which was talked of at the Health Commission in Belfast. That land there would be valuable. Along the Musgrave Channel we have no made up land; here this is all made up, all this is made up but we could make up a large quantity of land there. (*Indicating on chart.*) We own land from there southward, and the Commissioners will undoubtedly fill it up one day but they will not do it to-morrow, they only make up land as it is required.

31674. (*Mr. Stafford.*) One of the difficulties you anticipated in regard to the reclamation from the Kinnegar was that it might throw the nuisance further down towards Cultra?—I did not like to raise that difficulty, because it looks as if I were opposing this reclamation proposal, but I am afraid all the same that the difficulty will be raised by the owners of the foreshore and seaside residents.

31675. Where?—At Holywood especially.

31676. The Holywood Bank would be cleansed by the reclamation works; *ulva* does not grow there now?—I think when you hear what those gentlemen who are coming here to-day from Holywood have to say, you will find that some objections will be raised to the reclamation as proposed.

31677. Suppose it did, and suppose the result for one moment was that it threw this nuisance down towards Cultra, would it not be very much easier to collect it at Cultra?—If you do not object to the annual cost of collection, of course, you might dispose of it all in that way right along the whole foreshore.

31678. Would it not be a very much easier and cheaper thing to collect it from that very narrow foreshore there, than to collect it in these enormous foreshores?—Oh, it would surely.

31679. And suppose it were thrown down there, suppose there was a nuisance down at Cultra, how would that affect you?—Oh, it would not affect us in the City of Belfast.

31680. Not the least bit?—No; that is the reason why I do not care to say anything about it. It is for the owners of property below Kinnegar. It is altogether their concern.

31681. (*Chairman.*) There is one other point. We have had a letter from the Bangor Urban District Council who are apprehensive as regards the dredgings of Belfast Harbour that the dredgers will be emptied outside the entrance to Belfast Lough, and will thus do them damage. They say they fear if they were emptied at a point five miles beyond an imaginary line drawn across the entrance to Belfast Lough between Black Head and Orlock Point. Is there any likelihood of their getting damage from this or from such operations as you have conducted hitherto?—I have not the slightest idea of anything of the kind. Now we are depositing in deep water, we are obliged to deposit all our dredgings just about there, and the captains of our vessels have to send in a log every week, by which they must satisfy me that they have deposited all the dredgings in 10 fathoms of water which is the depth of the water in our depositing ground. Will anybody imagine that these dredgings could find their way to the Copeland Islands or to Bangor. I think the thing is very far fetched. The residents of Bangor may have seen *ulva* growing there, but to say that the sewage tipped in at Blackhead was the cause of it, they might as well say it was carried across to Scotland, and deposited there.

31682. (*Mr. Stafford.*) Suppose, as the result of all this work of reclamation you improve the scour, would your Harbour Commissioners be prepared to pay the Corporation of Belfast something?—Upon my word, that is an awkward question to answer.

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Twin Islands, and, of course, better still the nearer the land is to the city; there is no question about that.

31683. Has it struck you that your scour might be improved. You are claiming damages on the other side?—I will not say the scour will not be improved. I do not think it right to dogmatise, but I scarcely think it is at all likely that it will be improved. There may be some extra dredging required, but then the Harbour Commissioners might get a return for that extra expenditure in the valuable land made up; it might be worth their while to incur this extra annual cost.

31684. They might be paid over it?—They might. I am not speaking simply on my own dictum; some very eminent members of the Engineering profession have reported on this subject of reclamation. I think the Commissioners have a copy of their reports, and very valuable reports they are. Every one of these engineers has reported against extensive reclamations. (*Mr. Thompson.*) With regard to the sea wall which has been foreshadowed here that would require to be very, very strong. Now, when we are constructing the new dock we are building at present, the contractors, a very eminent London firm, found one row of sheet piling not sufficient to keep the rush of the thing coming out. They had to put in one row of sheet piling square timber, about 15-inch timber each way, all tongued and grooved. Then they had to make an embankment, and then put another row of sheet piling so as to make it strong enough to keep out the rush of the tide when they were constructing this wall.

31685. (*Chairman.*) At what part of the harbour?—That is the new dock we are building at present between Musgrave Channel and the Victoria, a new graving dock. (*Mr. Kelly*) We are building a new graving dock. (*Mr. Thompson.*) This is close to the city, and yet the inrush of the tide was so strong they had to put a row of sheet piling, then a row of clay, then another row of sheet piling. I want to warn you if you adopt a sea wall it will have to be a very strong sea wall. (*Mr. Kelly.*) It will have to be a very strong reclamation wall. Mr. Cutler will have to take into account that it would be much more exposed there, than where he is carrying out the embankment here. The same pitching there would not do, but that again is a matter of pounds, shillings and pence.

31686. (*Mr. Tatton.*) Is it the inrushing of the tide or the storms?—It is very much exposed, that channel.

31687. The storms?—Yes; the storms from the east. The east wind blowing sends the sea up there. (*Mr. Thompson.*) The permanent wall would be subject to the storms. (*Mr. Kelly*). It would be a bank with about three to one of a slope; that is the batter or gradient of the bank, a pretty heavy bank would be required, and I see that Mr. Cutler is keeping back the line of his embankment on the slob a good deal to the eastward of the line first proposed.

31688. You advocated taking all the sewage right out to Blackhead?—(*Mr. Thompson.*) That would be my view. I speak personally now, not as representing the Harbour Commissioners, that is my own personal view.

31689. Have you any estimate; has any estimate been made?—I have heard it put at £350,000. I cannot speak of my own knowledge that that is the amount. If that will do it would be cheaply done and should work.

31690. (*Colonel Harding.*) What would the people say at Blackhead?—There is very deep water at Blackhead; there is nothing to fear there.

31691. What about the landowners at Blackhead, will they take that view?—It is all going there now. If not taken by sewer we take it by dredgers.

31692. (*Mr. Stafford.*) Would you take it by the banks?—My own idea would be to take it round by the banks—a metal culvert tube.

31693. Would you not have objection from the other side, the County Down side?—The Main Drainage Scheme carries all the sewage from the County Down side to the County Antrim side.

31694. You would still have the Holywood polluted?—I understand they have abandoned that idea; they are to take all round by the Antrim side.

31695. (*Chairman.*) Would it go by gravitation?—They have to pump it at present; there are two pumping stations.

31696. You would have to get considerable head to get it all that distance?—Oh, yes, that would be quite necessary. (*Mr. Thompson.*) Instead of the low level sewer there at the present time it would be a high level. If they carry out the system they are thinking of now it would be a high level system pumping up from the very first, and then gravitating.

31697. Well, we are very much obliged to you for the assistance you have given us here and at Belfast.

Councillor GEORGE MURDOCH, the Chairman of the General Purposes Committee of the Holywood Urban District Council; and Mr. DAVID BELL, the Town Clerk to the Holywood Urban District Council, called in; and Examined.

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31698. (*Chairman.*) Mr. Murdoch, you are Chairman of the General Purposes Committee of the Holywood Urban District Council?—Chairman of the General Purposes Committee of the Holywood Urban District Council.

31699. And Mr. Bell is Town Clerk?—Town Clerk and Executive Sanitary Officer.

31700. We have your notes of evidence here, and you are going to tell us about the material changes which have taken place in regard to the foreshore and the growth of the weed during the past thirty-five years?—(*Mr. Murdoch.*) Yes.

31701. I think you had better give us that historically first, and then we will come to the effect upon the production or otherwise of nuisance by the various changes which have taken place?—Well, shortly, Sir, I was born in the town of Holywood, in the house that I reside in, within about 120 or 150 yards of the shore 53 years ago. I was brought into work there on account of the Holywood Pier Company, when there was a tremendous amount of sand all along the shore. One of the ways that they made their money was by selling sand, and I had something to do with the getting of this sand, and putting it into lighters, and weighing it and selling it, as my uncle was Harbour Master. The first thing that I remember with regard to the shore was that in the year 1873 on the whole shore there grew a wrack called Holywood Hair. That was the name this wrack had; it was about one-eighth of an inch broad, it grew to 4, 5 or 6 feet long, and it was used and gathered and sold by different parties to upholsterers, for the upholstering of chairs and beds, also mattresses, and that was used generally over the whole county. I want to show you that at that time there was no sewage on the shore because the whole place was covered with sand. About the year 1873 this weed began to break off prematurely, instead of waiting to the end of the year at harvest, in the ordinary way, it began to die off early in the season. Now the reason that was given for that was on account of some of the works in Belfast, especially vitriol works, sending down certain acids into the tideway that cut off this weed prematurely, before it was ready to come away in the ordinary way; that was the reason given by the fishermen at that time for this premature decay.

31702. That was in 1873?—That was in the year 1873.

31703. And did that materially reduce the crop that was gathered for this purpose?—It did.

31704. It began to diminish in 1873?—It did, and it ultimately went away altogether. Yes, and it does not grow now. No.

31705. Ceased to grow altogether?—Ceased to grow altogether.

31706. How long ago?—It would be about fourteen or fifteen years ago since it ceased to grow altogether.

31707. By 1880?—There was another wrack about the thickness of that pencil. It was like the leather whang of a boot; it was 7 or 8 feet long; it grew from any length up to 7 or 8 feet long.

31708. That was a narrow weed?—No. That was a round weed like a boot lace. Well it was about twenty years ago, or twenty-two years ago, that it disappeared;

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that was not the weed called Holywood Hair, that narrow weed; about twenty-two years ago the smell was very bad in the Kinnegar, and at that time what came in was crude sewage (it was not weed, it was crude sewage) for two or three years. Now, that was the sewerage that you will read of in the different reports, that blackened the silver in the people's houses, and blackened the brass.

31709. Was that a luxuriant weed at all ?—There was no weed of any consequence.

31710. What part of the foreshore are you speaking of now ?—I am speaking now about the Kinnegar.

31711. In days when there was no accumulation of sewage, and no particular growth of *ulva* in the neighbourhood of Kinnegar; there was sewage coming there which gave off emanations which blackened paint, do you say ?—Yes.

31712. That would be about when ?—It is about twenty-two years ago; about the year 1888 or 1889; and at that time the nuisance was very bad, and the smell was worse then than it has ever been either before or since. That was the worst time with regard to this nuisance.

31713. And that smell existed without any sea weed piled up on the beach ?—There was no sea weed piled up on the beach at that time, at least worth speaking about. There was a little, but not very much. Afterwards it began to come in largely, and it was impregnated with sewage. You would have seen the evidences of the sewage along the beach that had come in during those prior years if you had dug down, or if you had lifted a stone; the sewage was thick. If you had lifted a stone on any part of the beach, below you would have smelt the bad smell and seen the sewage that had filtered through the sand.

31714. (*Colonel Harding.*) Was this at Kinnegar ?—It was all over the whole place, and at the Kinnegar.

31715. Kinnegar; near Holywood also ?—Near Holywood, yes.

31716. How far was Holywood itself to blame ?—In that ?

31717. Yes.—It was not to blame at all.

31718. (*Chairman.*) Has it no sewage discharge at all ?—It has, but our sewage is so diluted with water.

31719. (*Colonel Harding.*) What is the method of treatment you adopt ?—We do not adopt any treatment.

31720. Then where is the dilution that you speak of; is it in the river ?—Yes, it comes from rivers.

31721. What is the length of the flow which gives you this improvement in the result ?—Of course, that is a question I would say more for an engineer.

31722. As a matter of fact, you say it flows into a stream, and becomes to some extent settled and purified ?—Yes.

31723. What is the length of the flow before it reaches the beach ?—Before it reaches the beach ? Well, of course it varies in one of the cases with regard to these rivers the overflow from the waterworks first comes in. The sewage from about twenty tanks from the better class houses comes into this river, and I would say from about 100 water closets. Sewage from ordinary houses also comes into this.

31724. What distance from the shore does it come in ?—Well, right down to the shore; within a very short distance of it.

31725. Half a mile ?—No.

31726. Quarter of a mile ?—150 yards.

31727. Then you claim that your sewage delivered on the shore is not crude sewage. It is settled in this stream ?—Oh, it is crude sewage, but it is crude sewage highly diluted.

31728. How ?—It is highly diluted with river water.

31729. Does that do away with the evil ?—It does not.

31730. It does not ?—No, I do not say it does

31731. Does it to any important extent ?—It does to a very great extent.

31732. (*Mr. Tatton.*) What is the population ?—We have a population in Holywood of 3,840.

31733. (*Chairman.*) Have you a water supply ?—We have a water supply. We have 192 dry closets in that population. We have 800 to 850 houses, and I suppose there would be about the same amount of water closets, because there are a good many houses that have two water closets in them.

31734. What is the consumption of water per head, do you know ?—We consume between 70,000 and 75,000 gallons a day. We have no works in the town, good bad or indifferent.

31735. (*Colonel Harding.*) Does your local authority propose to treat its sewage ?—Yes, we will ultimately treat our sewage, but there will be no use treating our sewage until Belfast treats theirs.

31736. But you claim that your sewage is not an evil, although there is only a certain small dilution ?—No, I do not claim that our sewage is not an evil, but I say we are blamed for our sewage growing a good deal of this *ulva latissima* on the shore, which is not a fact. It has been stated in different reports. Well, how I know is this; I am a member of the Joint Board, and time and again I could show you along the shore where there is anything from six inches to a foot of this *ulva latissima* lying on the shore close up to the Battery. A southerly wind comes and after the next tide you could not get a barrow load over our shore, proving it does not grow there.

31737. (*Chairman.*) But you have not told us when the *ulva latissima* began to be piled up on that foreshore. What year was that ?—1885. A few years after that, about fifteen or sixteen years ago; it began in a small way till it got gradually larger and larger.—The quantity ? Yes.

31738. Was the growth of it ever established on that foreshore, or is it only that you get the detritus that comes from elsewhere ?—We get the detritus. There is a growth on our shore more or less, but the growth on our shore is very light, because there is still a certain amount of sand and stones on our shore. Now, this *ulva latissima* does not grow on sand; on pure sand it will not grow.

31739. Then sixteen years ago it began to appear on your shore, and was anything then done by way of clearing it away; had it become troublesome to the extent of requiring removal ?—It had, and our Council cleared it for three or four years at small expense.

31740. Within your own area ?—Within your own area and of course the farmers always took a certain amount of it away in carts, that they used for manure.

31741. To put on the land ?—To put on the land.

31742. Well, you were beginning to suffer in this way. Did you hear they were suffering in the same way, or to a greater extent, westward, from the same trouble ?—Further down and further up from us they did suffer; they suffered worse at Tillysburn, because it comes in in larger quantities at Tillysburn, and in Cultra Bay it comes in very bad, because of the way that wall was built at Cultra. It seems to hold it in a sort of a segment of a circle; and it can't get away and rots there.

31743. (*Colonel Harding.*) Hold what ?—To hold the weed; whenever it gets in, it cannot get away.

31744. (*Chairman.*) What holds the weed do you say ?—The way the wall is built along the shore.

31745. At what date did the nuisance become so great that there was an Association of the authorities to deal with it, without respect to particular areas ?—There were three Boards formed. I think the first one was in about 1890; that is when the first Board was formed.

31746. Was that a constituted Joint Board ?—A constituted Joint Board; a sort of constituted Joint Board. It was before my time on the Council. That is the reason I cannot give you, from my own knowledge, particulars with regard to it, but the Joint Board proper that is in work at the present time I am a member of, and have been from the first, and I think I have taken as much interest in it as anybody.

31747. I just want to get this. The first Board; did it operate throughout the whole area from Sydenham down to beyond Kinnegar Point ?—It did.

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31748. It practically operated throughout the same area as the present existing Board ?—Yes.

31749. And cleansed throughout that area where cleansing was required ?—Yes.

31750. Was the cleansing limited to high water mark, or did it extend to the banks ?—It was limited to high water mark. We have really never gone to the banks, not even this Joint Board.

31751. And did that first Joint Board, so far as you know, effect some considerable improvement by their operations ?—They did.

31752. Reduced the trouble and nuisance to some considerable extent ?—They did.

31753. How was it that the Board ceased to operate ?—Well, they had not enough money to work; they only had, I think, about £400.

31754. Per annum ?—Per annum.

31755. Then was there an interval before the second Joint Board, with which you are more intimately concerned, was established ?—There was, but I do not think Holywood took very much to do with the second Joint Board, because they could not afford the money, and they thought they would do the work themselves, and indeed, they spent as little as they possibly could help.

31756. And in the interval between the cessation of the first Joint Board and the establishment of the second, was there any marked increase of the nuisance ?—Yes, it has increased ever since.

31757. In spite of the operations of the second Board ?—Yes.

31758. Then have the operations of the second Board been very largely increased as time goes on, or remained much the same year by year as to the total amount of weed that has been cleared away ?—Well, that is this present Board you mean; this present Joint Board that is in operation now.

31759. Is this existing Board the third Joint Board ?—Yes, it is the third Joint Board. I could not tell you very much about the first or second Joint Board, but with regard to this third Joint Board——

31760. How long was the second Joint Board in existence; can you tell us that ?—It was only a year or two.

31761. Only a year ?—Only a year or two; I would not exactly say, but I think it was only a year or two.

31762. And the interval between the second and the third ?—The third followed the second as soon as they could get their Bill, and they could get the local Government Board to take their case up.

31763. The nuisance was so far urgent that you could not afford to wait longer than was absolutely necessary ?—The thing was urgent, and with regard to the quantity and the approximate weight of the weed, this last year was the biggest year ever we had for the approximate weight, that is the weight in tons. There were 14,687 cartloads, 16,496 bogey loads, which meant 20,620 tons. That was in the year 1907. In the year 1908 there was not so much. There were 9,412 cartloads, and 13.537 bogey loads, and the weight in tons was 16,921¼ tons. Now, last year the cartloads rose from 9,000 to 20,730, and the bogey loads to 22,239; that was from 13,000; nearly double. The weight in tons was 27,798¾ tons; that was last year. Of course, I say this, that in 1907 and 1908, we could easily have got 27,000 tons if we had had as effective an administrator looking after things. We got a new man here, and he effected a very great difference in the quantity that we got weekly for the same amount of money. I have the particulars of the money that was laid out lifting the different quantities in the years 1907, 1908 and 1909.

31764. We will not trouble you about the cost of it at present, thank you.

31765. (*Mr. Stafford.*) How do you work; by contract ?—No, we do not work by contract. We have the men, and we pay them so much an hour. These are the different weekly reports that come in, showing the depth of the weed each day off different parts of the shore. (*Paper handed in.*)

31766. (*Colonel Harding.*) Has the work done any good ?—It has done good.

31767. It has reduced the evil ?—It has reduced the evil; that is, the evil is not so bad. If the weed does not get leave to lie long enough to rot, if you can lift the weed when it comes in fresh and cart it away, there is no smell, but if the weed gets leave to lie along the shore for two or three weeks until it smells and turns into a rotting black mass, then the incoming weed coming on to the top of it turns into a rotting mass so much quicker.

31768. Would it be impracticable for the Joint Board to do the work effectively ?—I believe absolutely it would.

31769. Why ?—Because it would take all the men in Holywood; if they were doing nothing else, they could not keep the shore clean from one end to the other. Certainly if we had more money, and more men, we could clear more weed, but I do not believe at the present time that we lift half the weed which comes in.

31770. At what cost do you lift half the weed ?—Well, at about £1,500 a year.

31771. You mean not half the weed deposited by the tide at high water mark ?—Half the weed that comes into the bank.

31772. (*Chairman.*) That is piled up by the tide ?—No, we do not.

31773. (*Colonel Harding.*) Your total income is £2,000 a year ?—Yes, but we only have about £1,500 a year to spend.

31774. At a cost of £1,500 you remove half the weed ?—Well, I would say about one third the weed.

31775. At a cost of another £1,500 you would remove the whole of it ?—Well, I would not say that.

31776. It is a matter of arithmetic, is it not ?—It looks like it. There are a lot of circumstances have to be taken into account in the lifting.

31777. (*Chairman.*) Have you any difficulty in getting labour for the purpose ?—Sometimes there is great difficulty in getting labour, and you see there is the thing with regard to the carts. I will tell you what would knock you out with regard to the farmers' carts that take away 20,000 tons a year. They could not take away any more, because you cannot get any more farmers. They take away just what they require, and they would not take a load more though you paid them; so that is one way your calculations would be out of it.

31778. What do you do with what the farmers do not take away ? Do you stack it ?—We have to stack it in Colonel McCance's field, and that is a very bad arrangement.

31779. That is in itself a nuisance ?—It is a nuisance, and when it was proposed to put it in that field, we had no idea that it was going to get leave to stay. Colonel McCance, once he got it there, would not allow any other carts than his own to come in and take it; therefore, it had to stay.

31780. (*Mr. Stafford.*) You only take what is thrown up on the shore ?—We just take what is thrown up on the shore, and no more.

31781. Would it not be better, so far as this nuisance is concerned, if you went out further, and got at some of the rotting masses that we see outside ?—It would if you could get out.

31782. Is it impossible to get out ?—Very nearly, because the men would be working up to their knees and their thighs. It is not long since I saw a man up to his neck. He would be absolutely engulfed in it; and close to the shore at Sydenham Station I saw a man up to his arm-pits, when I was in the train.

31783. Could you not work rails out, and work at low water ?—No, rails would not be very much use because the place is so soft that you could not work it with bogies and rails; at least, that is my opinion.

31784. Then no matter how much you spend upon it, apparently you cannot have an effective system of cleansing the foreshore ?—No matter what you spend.

31785. Would it not be better to reclaim that foreshore ?—Certainly.

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31786. You agree to that ?—I agree ; partial reclamation is the only way to get value for your money.

31787. Where would you reclaim from ?—I would reclaim the whole flat where that weed grows.

31788. From the Point Kinnegar ?—From the Point Kinnegar to the point of the Musgrave Channel at Twin Island.

31789. Would Holywood bear any portion of the expense ?—It would not ; it would not be within their district ; it would not be fair to ask them.

31790. It would not be within their district ?—No.

31791. Is not Kinnegar within their district ?—No.

31792. But it certainly would benefit you at Holywood ?—It might, and it might not. The thing is this ; there is a certain amount of this weed grows outside Holywood, and it might turn round if the scour was not strong enough to take this out to sea, and throw it back on the Holywood Bank, and make it as bad as Tillysburn Bank is at the present time, because our shore is lowering to the extent of 4 or 5 inches every year. It has been lowering to that extent this last twenty or thirty years.

31793. Anyway, you think it would be of great benefit to Holywood and the whole foreshore if you reclaimed it ?—I do. Some people might laugh at that. During the last two years, since the Harbour Commissioners begun to cut the channel, since they begun to deepen the channel for those big steamers that are building for the White Star Line, our shore has gone down to the extent of nearly 6 inches per year. The toe of the battery used only to be showing ; now it is a good bit down the foundation.

31794. Is that from the wash ?—That is from the wash, from the scour that comes over the bank.

31795. What are you going to do with your own sewage ; are you to purify your own sewage ?—We will purify our own sewage whenever the time comes, whenever Belfast do not throw any of their sewage out on to the bank. It is like this ; we have about £4,000 a year altogether to spend in Holywood from the rates. We have nearly £2,000 to pay for the poor rate ; we have the other £2,000 left. Now, it would take an extra 6d. or 1s. rate to purify. We have 3d. in the pound to pay in Holywood for the cleansing of our foreshore at the present time, whereas Belfast gets off with one-third of a penny, and Castlereagh Rural District with 1½d.

31796. Does not the Corporation of Belfast pay 95 per cent. of the whole of the outlay ?—They pay 85 per cent., one-third of a penny in the pound on their rates ; and with us 7½ per cent. is 3d.

31797. Well, now, about this sewage of yours ; you say it is very highly diluted ?—Yes.

31798. Have you had any analyses made of it ?—My friend there has made the analyses.

31799. That is Dr. Letts ?—Yes.

31800. I see that he has, and I also see the analyses of Holywood sewage. Amongst other things he states that they were rather more concentrated than Belfast sewage ?—I think you know, maybe, if he were taking other samples again, that they would not be so bad as these were, because that was for a certain purpose.

31801. Those were taken in 1908 ?—Dr. Letts at that time asked me in the Corporation one day, what came about with our sewage, he could get so little solids from it, with the other things in it, that is from a chemical point of view, and I pointed all this out to Dr. Letts, and you remember, Dr. Letts.

31802. (*Professor Letts.*) No, I cannot say I do.

31803. (*Witness.*) But I remember it distinctly.

31804. (*Mr. Stafford.*) You think it is better now ?—I think you could do whatever you like with analysis.

31805. What have you done since 1908 to make it better ?—We have not done anything. We flush our sewers well and we do not do anything more.

31806. (*Mr. Tatton.*) Perhaps he came on washing day ?—He might ; you can come on any day.

31807. (*Colonel Harding.*) Does not Belfast do a little more than that ; are they not settling a large part of the sludge and carrying it out to sea ?—They have been settling a lot of things for years, but none of them have improved our shore.

31808. They are doing a little more than you are ?—I could not tell you ; I do not think so. They would make you believe that they were, but I do not think they are doing any more than we do. The idea of comparing a town like Belfast with a town like Holywood, having regard to the population of the two places and the figures given, is simply ridiculous with regard to sewage. Mr. Cutler would make it out that there was more sewage came out of Holywood than out of Queen's Island, a place where there are ten times more men at work than adults in all Holywood.

31809. (*Mr. Stafford.*) Anyway, you appear to think that the real cure for this matter, as far as you are concerned, is the reclamation of the foreshore ?—Is the reclamation of the foreshore.

31810. Which of those weeds (*Showing illustrations of weeds*), were the weeds you remarked in 1873 as growing upon the foreshore, do you know ?—This was the weed there. (*Indicating.*) But there was another weed that grew too.

31811. That is zostera marina sea grass ; was there any *ulva* at all then ?—There was no *ulva* at all then.

31812. That was in 1873 ?—The *ulva* has changed. Within the last year there is far more foggy matter in the *ulva* now than there was in previous years.

31813. (*Colonel Harding.*) Far more what ?—Foggy matter ; like a foggy weed.

31814. Could you describe that a little more plainly ?—You would know what a spider's web would be like.

31815. You mean of a more mossy character ?—A more mossy character ; it has changed within the last two years.

31816. Then that would not be *ulva* ?—No, it is not *ulva*.

31817. And it probably is not a nuisance ; that does not wash ashore, does it ?—Well, it does not deteriorate to the same extent as quickly.

31818. What really causes the nuisance is not the foggy growth or the sea-grass, but the *ulva* proper ?—The *ulva* proper, because the *ulva* holds so much sewage in solution with it. Now within the last fortnight I saw a block of old *ulva* come ashore ; it comes ashore in blocks sometimes. Well, in turning up the bottom of that, it was altogether about 6 inches deep, there was from half an inch to an inch of entirely dark matter that seemed to be the bed that it had rested on, that it brought with it. That seemed to me to be pure sewage.

31819. (*Chairman.*) It had carried away the mud in which it had been imbedded elsewhere, you mean ?—Yes.

31820. (*Colonel Harding.*) That is a controversial point, of course ?—Oh, but I saw this ; there is no matter of doubt about it.

31821. You would see the mud, no doubt, but it did not follow that it was pure sewage ?—It did not, but I saw in one of these reports that Dr. Letts said this was old *ulva* we had. Well, I do not believe in it, because I believe that the old sewage that is on that bank would extend to 3 or 4 feet deep, and that when it gets the sun it ferments and comes away with the weed adhering.

31822. Would you mind smelling that rather evil-smelling bottle. (*Handing phial to witness.*)

31823. (*Mr. Stafford.*) Is that *ulva* or sewage.

31824. (*Colonel Harding.*) Is that sewage ?—It is more like sewage than *ulva*.

31825. That is absolutely vegetable matter ?—That might all be, but it has not that smell.

31826. You have no confidence at all in the opinion of Professor Letts in that matter, as to whether this mud is vegetable in its origin ?—Oh, as far as that is concerned, the scientific part of it, he may have his opinion, and I am like the common people, I have mine. I believe to a great extent in what I see with my eyes ; because the opinion of those men—they chop and change——

31827. (*Chairman.*) The views of the District Council are, that so long as present conditions are maintained, the work of cleansing will have to go on, will it not, or even be extended ?—It will.

31828. Increased ?—There is no doubt.

31829. And is the Joint Board proposing to carry on operations to cope with the nuisance ; are they to carry away next year, in 1910, even a larger amount of seaweed than they did last ?—Well, we will do the best we can, and that will be their intention as long as they last, but, as far as I understand, the Board will be dissolved in August. The Act of Parliament gave them up to that time.

31830. They come to an end then, do they ?—Yes.

31831. There will be a question of establishing a fourth Board ?—No, the Local Government Board have the power to keep the Board on for another five years. (*Mr. Bell.*) They may reconsider the question of contribution if the Board goes on still.

31832. Who are the contributing authorities now ?—(*Mr. Murdoch.*) Belfast, Castlereagh and Holywood are the three contributing.

31833. In what proportion ?—Belfast contributes 85 per cent., 7½ from Castlereagh and 7½ from Holywood. But as I would like to point out to you again, the Belfast 85 per cent. only costs one-third of the penny in the pound to those in Belfast, to Castlereagh it is 1½d. and in Holywood it is 3d. What we say is fair would be *pro rata* rate of ½d. all round or ¾d. all round or 1d. all round, we care not which. We will pay our fair proportion, but we say we are paying too much.

31834. You would prefer that basis of contribution if the Board is renewed ?—We would, because it is the fair contribution that is thrown on the population, the valuation and everything else.

31835. Has Mr. Bell anything special to say ?—(*Mr. Bell.*) Yes, Sir, I should say in the first instance, as well as being Town Clerk and Executive Sanitary Officer of Holywood, I have also had a good deal to do with this Joint Board. The Secretary is in Belfast and he operates it from Belfast, but by arrangement with him the practical work is done through me in Holywood. The wages are paid and the cartage moneys paid through me, and I am in daily contact with the men. I also reside close to the beach, and pass it sometimes five or six times each day. I also wish to say, so as to show that I am not here in any grandmotherly spirit, but with the desire to get some termination of the position with regard to the nuisance so far, not only as Holywood is concerned, but the other adjacent parts, that while Town Clerk of Holywood, I reside at Marino outside the urban district and own property there which is situate in the Castlereagh Rural District. I also, in Belfast itself, own considerable property, with the result that this question affects me in the three different capacities, that is in my dual personal capacity, and as Town Clerk of Holywood. I naturally ought to serve the interests of Belfast best, as it affects me more in the rating than the other districts. I want to get at the subject from the best point of view, to see what is the fair thing to do and also to get rid of the nuisance, if that is possible. Now, Sir, I should like to take the matter according to the letter which I sent to your Secretary first, the material changes that have taken place in regard to the foreshore and the growth of the weed, during the past thirty-five years. Well, I can go back twenty-five years. I was born on the other side of the Lough at Carrickfergus, and have never been resident from the Lough, I have always resided on its shores, I have resided at Holywood side for twenty-five years. Prior to that I had also experience with regard to the river proper, having boated a good deal upon it and sailed a good deal in the Lough itself, and not only in the Lough proper, but in the upper reaches, in shallow waters, getting aground, knowing the conditions by getting aground, with the result I have had a very fair experience in that direction. And as to the question of this *ulva latissima*, and the detrimental effect on the foreshore, caused by the alterations and extensions, in connection with the Belfast Sewage System and the inaction of the Belfast Corporation in giving proper effect to the duties devolving upon them with regard to the sewage of the city, I will take those two together, Sir, and try to make my statement as short as possible. There is no question that the growth of this weed has increased and materially increased.

31836. In your boating days, did you find it growing on the upper reaches of the Lough ?—I did ; there is no question about that ; not to the same extent as more recently particularly since the inauguration of the present main drainage system, that is after the passing of the Belfast Main Drainage Act, and the main drainage system went not into the river, but further down the river into the Lough.

31837. Do you remember the condition of the Tillysburn Bank in those days ; did you ever get aground there in your earlier days ?—Yes, Sir. There was a good deal of mud in there and soft mud, not close in, because, where we would be racing, the boats would be more or less in the old Channel. You would not be more than 100 yards out of the Channel, going into a little bay perhaps to get the benefit of or shun the tide. Well, in those bays there was a good deal of mud, because I have seen a boat drawing about three feet of water sticking in this mud and the tide practically leaving her standing upright in the mud. There was not the great growth of the weed at that time which seems to be there now.

31838. (*Colonel Harding.*) There was a growth ?—There was a growth, but not to the same extent.

31839. What period are you speaking of ?—Well, I would now be speaking of, roughly, from fifteen to twenty years ago.

31840. (*Chairman.*) What is that ?—Between fifteen and twenty years ago.

31841. Were there mussels on the bank there then in any large quantities ?—There were mussels on the bank there as still exist, but cut into when the cutting through the bank was made by the Belfast Harbour Commissioners, which I think materially altered the question with regard to the mussels. The mussel now is a smaller mussel and it is a little more spread over the beach. For instance, opposite Holywood proper, there are mussels hove up, I mean hove up by their own growth, raised up above the level of the beach more so than they were in former years. With regard to the river, before the sewage was passed into the present main drainage system, I remember going up the river rowing, and it was practically filthy from the fermentation setting up the gases. You would see the bubbles rising quite distinctly, as I have seen them rise similarly in the Clyde.

31842. That is in the river proper ?—That is in the river proper when the Belfast sewage went in there at that time. Now, the condition of the river is entirely changed ; that is, it is practically a clean river now. You can see into the water now, which formerly you could not have done, and the banks seem more solidified if anything in form. In my rowing years it was impossible for instance to go ashore at any part of the river if you desired, unless it was practically at high-tide. In the past few years, going up there, I have observed parties go ashore at practically low-water mark. The condition varies with the sludge and mud. At various parts it has more or less cleansed itself and more or less solidified, I assume from less sewage being in it. From the inception of the Main Drainage Scheme I personally have seen what I believe to be a considerable increase of the growth of this weed. My opinion is, that the growth on the banks proper—and when I speak of the banks proper I mean the banks of course which bare at low water—is immaterial and that the main growth, the growth which really causes the trouble, is a growth which takes place below low-water mark, and becomes detached. I should observe here that there are practically two detached portions of it, or rather two growths of it in the year. I have always observed, in the operations of the Joint Board, that early in the year, May and June, as a rule, give us a good deal of work ; that is there is a good quantity of the stuff seen then.

31843. In May and June ?—In May and June. I am speaking generally now, because it may alter somewhat according to the season. What I mean is that there is practically a spring growth of it which first comes ashore. After that does come ashore, Sir, there is a period during which there is seemingly a second growth, which is driven ashore in August, or sometimes in September.

31844. The May and June growth that is driven ashore ; are those immature fronds ; are they as large fronds as come in the autumn ?—They do not seem to be quite as

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fully developed as the autumn growth; as a rule it is easier dealt with at that time of the year. Now, last year for instance, September month was pretty warm, and I noticed at my own place that we had at that period an extra growth of grass on land. There was a very heavy growth of *ulva* came in during the month of October and there were deposits of weed—I should say thousands of tons—taking it over the whole shore—which had been blown in by heavy seas at that period, and the Joint Board's operations having ceased it was not removed except by the farmers. Fortunately, that was a period of the year when the farmers could give a good deal of their time to its removal.

31845. When did cleansing operations cease last year ?—I think it was about October. We had a little more money in October last year than we had the prior year, not larger contributions, not a larger revenue, but we had more to the good at that time owing to the manner in which it was expended in the earlier months.

31846. But this extra delivery of *ulva* on the foreshore was subsequent to that, was it ?—It was, Sir. It practically came in just as the Board was ceasing work. There was a fair quantity of it taken away by reason of it coming in at a period when the farmers could take it, because in the summer time, probably early in the month of August, you cannot get the farmers, they are harvesting, and they will not send their horses to take away the weed. If it comes away in October, if the weed is on the beach then, they will come and take it in large quantities. I have seen fifteen or twenty farmers last October clearing away this weed as fast as they could get it, every day. My impression is, rightly or wrongly—I do not set myself up as an expert—that the alteration of the Main Drainage Scheme of Belfast has increased the nuisance by causing a larger growth of this *ulva* which is deposited upon our beach.

31847. From what date should you say that difference commenced ?—The year 1887, Sir, the date of the passing and putting into force of the Main Drainage Act. Now, up to that year there was a bathing station at Cultra of which I was a very interested member, in fact I bathed daily. I bathed after that period until about four or five years ago, when the water began to be so bad down in that direction that I refrained from bathing, and have not bathed there since. When this weed would rot on the shore, and the water would come in and mix with it, the water got to be of an inky nature and that would be passing down with the ebb tide and, of course, when you are bathing you are not going far out. This blackish water would be on the edge of the receding tide sometimes, and if you got a mouthful of it, it was not very pleasant. I have refrained from bathing entirely, and from that date I have seen that the growth that has been deposited has increased. In fact, if this Board had not been formed, the conditions that existed with regard to Cultra and the colouring of the boats and the club house and all that, would at any year now be equally as bad as on any occasion that Professor Letts in his evidence gives it. I have seen myself what Professor Letts has spoken of as to the action of the sulphuretted hydrogen on the paint and the silver in my own house. The watches of the men working on the shore, and the money that they were handling and in their pockets were turned absolutely black. This all leads me to the conclusion that the difference in the effect of the drainage of Belfast has materially increased the weed. I presume the members of the Royal Commission are thoroughly aware that there is not a nuisance to any great extent, or rather what could be called a nuisance, apart from the weed rotting, I wish to say, the amount of sewage deposited on the beach to my mind would not cause a nuisance sufficient to trouble us, that it is the weed coming in and rotting that sets up the fearful nuisance and the fearful smell which are so often complained about.

31848. (*Colonel Harding.*) What are the remedies that you suggest ?—Well, since the invitation I should say has been sent out by the Royal Commission with regard to this sitting here, it has been suggested that this reclamation already referred to should be adopted. That had been considered before but it had been evidently pooh-poohed, or at all events was never pushed; that is so far as we are concerned. I understand now there is a desire to change in that respect. I personally was always under the impression that reclamation would assist it in this way, that it would give a smaller space for the stuff to come ashore and begin to rot before it was lifted, because Tillysburn and Sydenham are the two places where they have great difficulty in removing it, not only owing to its position, but owing to holes which had been made by prior buryings of the stuff by the temporary Joint Boards which have been referred to here rather the temporary arrangements between the districts surrounding. What they used to do was to dig holes and bury the stuff, with the result that there are numbers of these holes yet existing where that stuff is lying in a black putrid condition, and I have seen the men getting into them, and on some occasions risking themselves considerably by dropping into one of these holes.

31849. On the foreshore ?—Yes. Those of course are in the area where this proposed embankment for reclamation would be thrown across, but I should say with regard to that I question whether the reclamation there will have a very material effect so far as Holywood is concerned, and my reason is this. If it is right that the greater growth of the weed is below low water mark, and that is it not retained there, and broken away and deposited on the shore——

31850. (*Colonel Harding.*) I think, Sir William, it would be important if the witness would give us the authority upon which he bases the opinion that the weed is grown below low water mark ?—Not opinion; ocular demonstration. That is what I am giving you.

31851. That is a controversial point. We shall be interested in hearing something more about that ?—I remember at the last Inquiry, at which Dr. Letts was present, I gave the same evidence with regard to it.

31852. Where have you found the weed growing below low water mark ?—Well, I think the map possibly——

31853. Was it a floating weed or a growing weed ?—In some cases floating; I want to distinguish between what I saw floating and what I saw growing.

31854. By growing, what do you mean ?—I mean attached to some bottom.

31855. (*Chairman.*) Attached to stone or to mussels ?—I could not say that, for I did not look.

31856. Can you point out on the map where you found these beds below low water mark ?

31857. (*Colonel Harding.*) The argument you are just bringing before us is based upon this fact, that the *ulva* grows below low water mark ?—Yes, mainly.

31858. The embankment would not prevent its growth ?—It would not prevent its growth, but it would prevent what I say; it would minimise the nuisance in this way, that it would prevent it being deposited at a very, very bad part of the beach, that is between the Kinnegar and the Twin Island. Where it comes in there it is very difficult to deal with; the beach is soft and it rots there very quickly, I think more quickly than in any other part. That is between Tillysburn Station and the end of the Kinnegar.

31859. Please explain the observations upon which you base your opinion that the *ulva* grows most under low water ?—Take Cultra; this is Cultra bed here. (*Indicating.*) Professor Letts will follow me in this, because he knows Cultra very well. Between the one and the two-fathom line, I have seen beds of the stuff lying on what I may call a fairly clean sandy bottom. They were lying 3 or 4 feet deep. You could put the oar down into it.

31860. On a clean sandy bottom ?—On a clean sandy bottom.

31861. Mr. Murdoch told us just now that in no case had he seen the weed growing on a clean sandy bottom ?—I do not think he speaks of Cultra.

31862. In this case it was growing on the sand ?—I did not say so; I said it was there; not growing. That is what I want to explain. This was a season of the year when we would have what I might call an anti-cyclone period, with the result that there was nothing to drive the weed in; it was lying there for three or four days at least.

31863. I think that is pretty well admitted. There is much evidence before us to show that quantities of weed are found floating below low water, but you expressed

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the opinion that it mainly grew and was attached below low water mark ?—Exactly, but I wanted to distinguish between those beds at Cultra and a growing bed. Now I am coming to a growing bed, Sir, off here, off Garmoyle, here you see the old channel. It is there. (*Indicating.*) The new channel of course goes in a straight cut. In the old channel round here was the red light, and what is called the Garmoyle light in there. At the back of the Garmoyle light, I have seen it growing there in considerable quantities.

31864. You say you have seen it growing there ?—Yes ; what I mean is below low water mark.

31865. In what way did you see it growing ?—Going over it in a small boat, and seeing the growth below.

31866. (*Chairman.*) What depth of water would it be ?—Not more than 3 or 4 feet, verging out in absolute banks to the high water mark.

31867. (*Colonel Harding.*) Explain to us how you saw it growing, the attachment to the bottom ?—I did not take a handful of it up, or take any machine to take it up and see whether it was actually attached.

31868. Then you do not know if it was attached ?—Further than by the appearance of it. It seemed to be attached. With a moving or detached mass, any action of a steam boat or anything of that kind will move it in a different way from anything that is attached. What is attached will only show a small waving line, like growing corn. The other will move a yard or so in the oscillations.

31869. You did not pull any of it up to prove whether it was attached or unattached ?—No, I am giving you my reasons for saying I think it was attached.

31870. It does not go beyond that ?—No, I do not wish to state anything which would mislead the Commission, or place myself in an awkward position before them.

31871. You have seen the weed attached, say, on the Tillysburn bank, attached to mussels ?—Very little. I have said, Sir, that the quantity that grows on the bank, if that was all we had to deal with—I am speaking of the banks entirely exposed at low water—to my mind would be infinitesimal, and would not cause a nuisance.

31872. Have you walked over those banks in summer ; in August ?—In the winter-time.

31873. Are you speaking of the Holywood Bank or the Tillysburn Bank ?—I am speaking of the Bank off Holywood.

31874. Have you been on the Tillysburn Bank, near the mouth of the Connswater ?—No, Sir.

31875. There it is found growing attached in very large quantities ?—I do not touch upon that.

31876. So far as your statement of the weed growing below the low-water mark is concerned it is merely upon your inference that it was not carried away by the wave action when you saw it there, it was simply waving and remaining *in situ* ?—Just so.

31877. You simply infer that it was attached, but you have not verified that there was attachment ?—I have inferred from the other weed which would possibly pass away by the action of the water ; the oscillations would be much wider.

31878 (*Chairman.*) You tell us the embankment of the Tillysburn area might not have a satisfactory effect on the coast line east of Kinnegar ?—That is what I was getting at. From this point of view, if the weed does grow in quantities below low water mark, as I infer from my last answer, then that will sooner or later become detached and be sent down to reach the Holywood Bank, because it cannot get in where you have the proposed embankment with the result that my view is that the nuisance, as far as Holywood is concerned, would be materially increased by the deposit and of course the natural rotting of the weed.

31879. (*Colonel Harding.*) And if the weed does not grow under those conditions, what would be the effect ?—If the weed does not grow under those conditions, there cannot be the quantity of weed that would cause any nuisance. I would be perfectly satisfied with an embankment, and that it would not do any harm to Holywood. That is the inference perfectly clear ; that is ordinary logic.

31880. (*Chairman.*) Do you apprehend you would get weed transferred across from the opposite shore, the Antrim shore ?—I do not think that from the Antrim shore, as the shore itself, Sir, the weed would reach us, but if it grows below low-water mark, as I have inferred by one of my answers, we would get it with a strong westerly wind, because I have seen on occasions there with a strong westerly wind, even at high water mark, along our own beach on the south shore, the Holywood Shore, a greasy appearance with a quantity of sewage, on the top of the ordinary sea water. That is when there is a strong westerly wind with the ebb tide running, and there would be a discharge of the sewage from the Belfast Main Drainage Works.

31881. (*Colonel Harding.*) What are we to understand that you suggest to us as a remedy for the evils that are complained of ?—Well, so far as the Joint Board is concerned, the removal of the stuff before it commences to decompose will, to my mind, make the beach clean, because that is our experience. For instance, at the present time, just before we left Holywood, the beach was absolutely clean ; no smell observed, Holywood was absolutely clean. It is the remaining deposit that is the nuisance, and if the Joint Board's action is sufficient to clear away the weed and keep the beach clean—I do not speak of the banks outside, but the beach, say, within 100 yards from the embankments—my impression is that the nuisance would be greatly mitigated.

31882. You suggest that effective removal would be more valuable than reclamation ?—Well, I am in this difficulty, Sir, that my suggestion with regard to the growth of *ulva* is questioned. If I am right as to the growth it would effect us, because if the weed is kept below the low-water mark, there is no nuisance. It is only getting above low-water mark and by compression and decomposition setting in, the nuisance arises.

31883. You think it is a more certain remedy to remove the weed that accumulates at high-water mark first ?—Yes, but the more certain remedy to my view is—and here we may have some little controversy—that if the Belfast people will carry out the terms of the 1890 Act and treat their sewage by purifying it, they will, of course, starve this weed, and we will not have the weed in quantity ultimately ; it will practically cease to be a nuisance.

31884. You know that that view is not necessarily accepted ; it is a controverted view ?—That is why I say, there we will get into controversy.

31885. But any way, you are satisfied, so far as that district is concerned, that removal is an effective remedy ?—I believe it would be, if the removal were sufficient, but the cost of that would be pretty heavy ; to make an absolute removal, that is if there is a proposal to clean the whole banks, I do not think it will be possible.

31886. (*Mr. Stafford.*) I thought Mr. Murdoch said that was impracticable ?—My own view is, that it would not be practicable to carry it out, because of the condition of the beach at the present time.

31887. How would you carry it out ; how could you carry it out ?—Well, the only way it could be carried out would be by not only removing the weed that is there, but removing the sludge so as to make a bed upon which the men could work, which to my mind would be a most expensive thing. From my point of view, the reclamation would be much preferable.

31888. And cheaper ?—And cheaper in the long run. I think it was a great mistake—this must be taken for what it is worth—that at the time the Harbour Board made this new cut down Belfast Lough it was not shifted over to fill up this embankment, and for which error we will all have to pay or are paying.

31889. (*Colonel Harding.*) What has been the effect of the removal of the accumulated weed on your shore so far as it has been carried out ?—By this Joint Board.

31890. By this Joint Board ?—It has been exceedingly successful, according to the amount spent.

31891. Has any serious nuisance remained ?—This year I can be positive about that, that there has. After the Board ceased operations this year in Cooper's Bay, there was a very large deposit, and that commenced to smell very badly, and for some period was very bad indeed. That was in the months of October and November If it had been in the summer time we would, of course, have had the ordinary absolute nuisance.

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31892. As a fact, the operations of your Board have been to reduce the nuisance very considerably ?—Oh, unquestionably, Sir.

31893. And at what cost do you think the nuisance could be wholly removed ?—I had a view on that which I expressed before the Belfast Corporation Inquiry, and I have not very materially altered that yet ; that is, I believe the £2,000 if properly expended will go a very great distance in doing it. And my reason for that is this; there are some £600 or £700 which have to be paid in to repay a loan, for costs and other things in connection with this Board. I understand that the last payment of that ceases this year.

31894. Now, you have the whole income available ?—(*Mr. Murdoch.*) This next year ; it takes another year. (*Mr. Bell.*) It takes another year to pay it ; very well, that does not affect it at all. If that sum, in place of having to be paid for loan purposes, were available for cleansing purposes, it would mean a sum of £50 a week [take this as the average cost per week] for cleaning this shore. A very slight calculation will tell you how long that will extend. It would mean that this accumulation, which came in late this year and was allowed to rot and was so offensive, will all have been removed by the Joint Board.

31895. May I ask you further, do you think that this work of removal is now efficiently carried out so far as it is carried out ?—I believe it is.

31896. You think it is ?—I believe it is.

31897. You think that this gathering up in carts and trolleys and running it to Colonel McCance's field is a good way ?—I think it is, excepting as to depositing on to Colonel McCance's field. There is no other means of getting rid of it ; it causes a very nasty nuisance in itself.

31898, You have to do with the carrying out of this work ?—Yes.

31899. Would it not be possible to squeeze out a large part of the water by passing the weed through rollers ?—There is no doubt the weed could be lightened by that means.

31900. Is not that method carried out in your experience ?—I think it is with farmers in a manner. If they can get the dry weed they will not take the wet. When they go down to the shore they will wade their horses through the wet weed to get dry weed to fill the carts. They heap the wet weed and allow it to partly dry by its own compression.

31901. They do not want to take nine-tenths of the load water ?—That is it.

31902. Why does not your Board consider some way of gathering the weed and partially drying it, have any experiments of any kind been made ?—I am not aware that they have. The question of expense there would be a very serious one, because the arrangements for pressure would be to my mind expensive.

31903. I am rather surprised that your Board have not carried out some experiments ?—I will tell you why we think that it will probably become more expensive than you have considered ; the beach extends over such a distance that to bring the weed to one pressing arrangement would be exceedingly costly. You would require to have several pressing arrangements along the whole beach, and that is where it would become very expensive.

31904. It occurs to one, looking at it superficially, when one goes there, that this collection is done in a most inefficient manner, that it might very greatly be improved, and that it would be worth the while of your Board to consider whether, at comparatively small increased expenditure, they could not do the work infinitely more efficiently ?—I agree with you there, and last year a gentleman was brought on to the work who was more capable in dealing with the men, with the result, as the figures show here, Sir, that with practically the same expenditure he has got a much greater quantity of the weed gathered, and that in his first year, when I know myself in the first part of the season he was working against considerable difficulties.

31905. If you put the men on piece work, probably you would double the quantity you gather ?—(*Mr. Murdoch.*) They are on piece work. (*Mr. Bell.*) They are on piece work.

31906. I thought you said they were paid by the hour ?—(*Mr. Murdoch.*) This is piece work. (*Mr. Bell*) I see what you mean ; you practically mean to take it by contract.

31907. So much a ton, so much a cube yard or in some way measuring the work done ?—That would be all right, Sir, if there was a heap of stuff and you wanted it removed at so much per cubic yard, but you can take a portion of the beach where they could possibly fill up six carts in a very short time, and you could take another part of the beach where they could not possibly fill six carts in six times the time it would take them to fill up the others. It means the condition in which the weed is. In Cooper's Bay, for instance, there would be no difficulty in getting a contractor to whom you could say : "How much will you remove that for ?" Provided we do it at the one tide. One tide might shift it to such a position that it would greatly increase the expenditure in its removal.

31908. I do not want to take up your time at any greater length, you have already given us a great deal of information, but we may take it from you that the nuisance has been greatly reduced by the work already done in removal, and at a cost not necessarily prohibitive, the nuisance might be done away with altogether ?—I quite agree.

31909. And further you think there is a probability of considerable improvements being carried out in the methods of gathering this weed ?—I believe so. There is just one thing, if I am not taking up too much of your time. I should like to say, on theq uestion of contribution that Mr. Murdoch raised, I want to make it clear, just with regard to the valuation of property, as compared with Belfast, the population as compared with Belfast, and the quantity of sewage as compared with Belfast, my Council feel that it you take any of the figures which I can give, in no case does it show more than 1 per cent. so far as Holywood is concerned. To pay 7½ per cent. to a small community like Holywood, means a large rate to them. Compared with a large community like Belfast they feel it is rather severe on them.

31910. That is rather for the Joint Authorities who form the Joint Board ?—I understand it is ; I am only mentioning it here.

31911. (*Chairman.*) We are greatly obliged to you, Mr. Murdoch, and to you, Mr. Bell, for the assistance you have given us.

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Parliamentary powers would probably be required for the reclamation, 31268.

Ground outside the district would be dealt with, 31269.

Crown property, 31270.

Reclamation would probably not alter channels or affect navigation, 31271–2.

Plan proposed increases cost, 31273.

Two cradge banks would have to be made, 31274.

One outlet would be sufficient for the Silver Stream, 31275–6.

Reclaimed land would ultimately be valuable for agricultural purposes, 31277–8.

Reference to land in Victoria park of which the level was raised, 31279–80.

That land has not been used for agricultural purposes, 31281.

Weeds on that land, 31282.

And cattle grazing, 31283.

Methods adopted in dealing with land, 31284–5.

Land was not let, 31286.

(Memorandum handed in by Mr. G. B. Kershaw respecting reclamation and protection of agricultural land, 31287).

£1 10s. per acre would not pay for the proposed reclamation, 31287*.

Belfast more favourably situated for reclamation of lands than the Humber, Lough Foyle, or Morecambe Bay, 31288

Ulva nuisance would be practically done away with by the proposed reclamation, 31289.

Practically all the weed is growing in the area which it is proposed to reclaim, 31290.

But in the summer time there are great quantities of floating weed, 31291.

Doubtful whether same conditions would occur in new areas, 31292–3.

Conditions of slack water existing now at Tillysburn would probably not be reproduced at Holywood and Cultra or elsewhere as a result of the proposed reclamation of land, 31294–6.

Difficulties of the reclamation might come from action of the Harbour Board or landowners on the shore, 31297.

Probably no difficulties from the shore landowners, 13298 and 31300.

Difficulties could probably be met by an arrangement with the Harbour Board, 31301–2.

Harbour Board would probably reap great benefit from the reclamation, 31303.

Material to be scoured out of the Lough and the scour itself would probably be reduced in the same proportion, 31304.

Any *Ulva* carried away from where it grows probably goes out to sea, 31305.

Preparations have been made for experimenting on the removal of the mussel beds as an alternative to the land reclamation, results will be shortly reached, 31306–11.

Results of an experiment in clearing away mussels, no *Ulva* grows except where there is a small patch of mussels, 31312–8.

Mussel clearing at Southend referred to, 31319.

The effect was to remove the mud, 31320–3.

Clearing banks of mussels an alternative to land reclamation, 31326.

KING KERR, ALDERMAN J., M.D., J.P. ; COUNCILLOR CRAWFORD McCULLAGH ; CUTLER, H.A. M.I.C.E. ; ADENEY, W.E., D.SC. F.I.C., F.C.S. ; AND HAWTHORNE, JOHN, B.A., PH.D., (*Analysis of their Evidence*)—*continued.*

Premature at present to form any conclusion of the effect of clearing away mussels either as regards cost or in effectiveness, 31327–8.

Reclamation might possibly alter the set of the currents in the Lough, 31331.

Maximum velocity of ebb tide, 1½ knots, 31333.

Has practically no scouring effect, 31334.

Ebb stronger than flow, 31335.

A large amount of mussels are gathered at Carrickfergus, *Kerr*, 31338.

£4 10s. a ton paid for them, 31339.

But the mussels taken are mainly outside area involved in this inquiry, *Kerr and Cutler*, 31340–1.

The chute is constructed of wood, 31342–3.

Trouble in connection with the chute, *Cutler*, 31344–9.

A new chute would be very expensive, 31350.

Not proposed to construct a new chute till Belfast Corporation know what action they are to take in regard to their sewage, 31351.

Iron pipes or ferro-concrete tubes would be substituted for the wooden chute if alterations were necessary, 31352.

At a cost of about £20,000, 31353–4.

Were the sewage purified completely a chute would not be required, 31355.

No necessity to lengthen the present one, 31357.

Condition of chute has improved and sewage does not escape from it as it did, 31358–60.

Since the sedimentation of the Belfast sewage there is practically no trouble with deposit in the chute, 31361.

No trouble if a new chute were constructed, 31362.

Discharge of sewage independent of the chute, 31363-4

Storm overflow discharged into pond and slob lands, 31365–9.

Due to ineffectiveness of the chute, but discharge is small in relation to amount of the sewage treated 31370.

Sedimentation tank capacity being increased, 31371

Will probably be in use in six months, 31372.

Capacity will be sufficient to comply with suggestions of Health Commission, 31373.

Sewage storage : ponds under construction, 31374–6.

The works sanctioned by the Local Government Board will be completed in 1910, 21377–8.

Sewage will be settled and not precipitated, 31379.

Belfast is sending 180 tons of sludge each day to sea, 31380–1.

The Corporation have plenty of ground on which to put down precipitation plant if necessary, 31382–3.

Ulva flourishes most when close to sewage solids, not in the sewage itself, *Adeney*, 31384–5.

No material advantages would be gained from filtering the deposited sewage, *Adeney*, 31386–7.

No sign of serious pollution on the west bank, *Adeney*, 31387.

The liquid sewage matter gets into the Victoria Channel, *Adeney*, 31388–90.

Belfast Corporation have had to pay the Harbour Board heavily for the liquid sewage going into the deep water channel, for damage done, *Cutler*, 31391–4.

The *Ulva* on the Tillysburn area may derive its sustenance from the Connswater and the Lagan *Adeney*, 31395.

Improbable that Belfast sewage could cross the Victoria or old Channel and be deposited on the Tillysburn area, *Cutler*, 31399.

Solid sewage matter could not survive the pumping and screening operations in connection with the treatment of Belfast sewage and reach the Tillysburn area, *Cutler* and *Adeney*, 31401–7.

Float experiments with state of wind and tide, referred to, 31408–21.

Messrs. Harrison & Calwell's float experiments, showing different results, referred to, 31419–20.

Doubtful whether Belfast solid sewage matter could travel to the south shore, it would probably be deposited on the way, 31422.

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Difference in the smell of the mud on the Antrim shore on which Belfast sewage is deposited and the mud on the south shore, 31423.

Further purification of Belfast sewage beyond sedimentation would not reduce the nuisance from decaying *Ulva*, *Cutler* and *Adeney*, 31424–6.

Not necessary for Belfast to filter its sewage if it is settled, is discharged regularly, an effective chute is provided, and the slob lands are reclaimed or the *Ulva* is collected, 31427–9,

If no Belfast sewage went into the Lough there would still be trouble with the *Ulva*, 31430.

Particulars as to the working and state of the existing chute and cost of its repair, 31431–42.

Doubtful whether there would be any advantage in altering the position or extending the chute, 31443–6.

Capacity of the tanks, 31447–8.

Proposals for dealing with Sydenham, &c., sewage, 31449–52.

New sewers will be required, 31453.

Sydenham sewage scheme referred to, 31454.

McCULLAGH, CRAWFORD (*see under King Kerr, &c.*)

MURDOCH, GEORGE, Councillor and Chairman of the General Purposes Committee of the Holywood Urban District Council and BELL, DAVID, Town Clerk to the Holywood Urban District Council (*Analysis of their Evidence.*)

(*Personal statement and evidence of Mr. Murdoch.*) *p.* 49.

The shore at Holywood was originally sandy, in 1873 a useful weed called "Holywood Hair" grew there which died prematurely, owing, it was said, to the effect of certain works in Belfast, and is now extinct, 31701–6 *et seq.*

Also another weed at Kinnegar, which has become extinct, 31707–10.

No accumulation of sewage or of *Ulva* in 1888 or 1889, but very bad smelling sewage, 31711–2.

Very little seaweed at that time near Kinnegar and Holywood, but thick deposits of sewage could be found by digging, 31713–5.

Holywood sewage not treated; much diluted with water; but only runs about 150 yards to the beach, 31718–28.

Particulars as to population of, water-supply, closets, and consumption of water in Holywood, 31732–4.

No use for Holywood to treat its sewage till Belfast purifies its sewage, 31735.

Very little *Ulva* grows at Holywood, 31736 and 31738.

Ulva began to be piled up on the Holywood shore in 1885, and since then in increasing quantities, 31737.

Ulva does not grow on pure sand, 31738.

Holywood Council for a few years cleared off the *Ulva* thrown on the shore, 31739.

Farmers also use it for manure, 31740–1.

Ulva is worse at Tillysburn area and at Cultra because of the wall there which apparently retains it, 31742–4.

Three Joint Boards constituted to deal with the nuisance, the first in 1890, 31745–6.

Jurisdiction of the first Joint Board extended from Sydenham to beyond Kinnegar Point, 31747.

The same area as that of the present Board, 31748.

Cleansing limited to high water mark, 31750.

Improvement effected by the first Joint Board, 31751–2.

Ceased to operate for lack of funds, 31753–4.

Interval before establishment of the second Joint Board, 31755.

A marked increase in the nuisance in spite of the operations of the Joint Board, 31756–7.

The Joint Boards : the present is the third Board, 31758–62.

Details as to weight of *Ulva* removed in recent years, 31763.

Work not contracted for (paper handed in showing depth of *Ulva* each day off different points of the shore), 31765.

The work has reduced the evil. There is no smell if the weed is carted away when fresh, 31766–7.

MURDOCH, GEORGE AND BELL, DAVID (*Analysis of their Evidence*)—*continued.*

But the work cannot, practicably, be done effectively, 31768.
There is too much *Ulva* to clear away, 31769.
Present cost about £1,500 a year, 31770.
Less than half of the *Ulva* is removed for this money, 31771–6.
Sometimes there is difficulty in getting labour, and farmers will only take a certain amount, 31777.
Some is stacked in Colonel McCance's field, 31778–9.
The *Ulva* removed is part of that thrown up on the shore, 31780.
Practically impossible to get at the rotting masses further out, 31781–2.
The shore is so soft that rails cannot be used, 31783.
No effective system of cleansing the foreshore is practicable, 31784.
Reclamation would be better, 31785–6.
The reclamation should extend from the Kinnegar Point to the point of the Musgrave Channel at Twin Island, 31787–8.
Holywood would not bear part of the expense, it would be outside their district, 31789–91.
Doubtful whether Holywood would be benefited: owing to the wash the shore is sinking, 31792–3.
Holywood sewage will be treated when the Belfast sewage is no longer thrown on Holywood bank: Holywood local expenses referred to, 31795–6.
Analyses of Holywood sewage, 31798–804.
Nothing done at Holywood beyond flushing out sewers, 31805.
Nothing done by Belfast to their sewage so far has improved the Holywood shore, 31807.
Reclamation of the foreshore the cure for the trouble, 31809.
Zostera marina sea grass growing on the Holywood shore in 1873, no *Ulva*, 31810–1.
Change in the weed growing during the last two years, 31812–7.
Ulva coming ashore in blocks with mud attached to it, 31818–20.
The mud may be sewage, 31821–6.
The work of cleansing the Holywood shore will have to be increased, 31827–8.
Joint Board coming to an end, 31829–30.
Unless Local Government Board extend its life, 31831.
Constituent authorities of Joint Board, 31832.
Proportions of contributions: Holywood pays too much, 31833–4.
(*Personal statement and evidence by Mr. Bell*), 31835, *et seq.*
Ulva grew some years ago in the upper reaches of the Lough, but not to the same extent as at present, 31836.
Much weed 15 or 20 years ago on the Tillysburn bank; but not so much *Ulva* as at present, 31837–40.
Growth of mussels at Holywood: river much polluted before sewage entered the present main drainage system, 31841.
Great improvement recently in the state of the river: considerable increase in growth of *Ulva* below low water mark, 31842.
Principally comes ashore in May and June, a second growth comes ashore in August and September, 31842–4.
Date of cessation of cleansing operations, 31845.
Farmers clear away large quantities of the weed in October, 31846.
Alteration of Belfast main drainage system in 1887 has caused a larger growth of *Ulva*, 31846.
Effect of the rotting *Ulva* in preventing bathing at Cultra, and its blackening of paint and silver by emanations of sulphuretted hydrogen. The nuisance is caused by rotting *Ulva* and not by sewage deposits, 31847.
Reclamation of foreshore the best course to adopt: practice of temporary Joint Boards to dig holes in the shore and bury the *Ulva*, 31848.
Growth of *Ulva* below low water mark: discussion as to, 31849–57.
Reclamation would minimise the nuisance, 31858.
Ulva at Cultra lying on clean sandy bottom, 31859–62.
Ulva at Garmoyle: probability of growth below low water mark, 31863–70.
Very little *Ulva* grows on the Holywood Bank, 31871–3.
Inference from observation respecting growth of *Ulva* below low water mark, 31876–7.
Embankment by Tillysburn area might have an unsatisfactory effect at Holywood if *Ulva* grows in large quantities below low-water mark, but not otherwise, 31878–80.
The nuisance at Holywood might be cured by the removal of the *Ulva* from the beach, 31881–2 and 31885.
The most certain remedy might be the purification of the Belfast sewage, 31883.
But this is a matter of controversy, 31884.
Entire removal of *Ulva* at Holywood from all the banks impracticable, 31885–6.
Reclamation preferable and cheaper in the end, 31887–8.
Removal of the *Ulva* from the Holywood shore has in effect been successful according to the money spent, 31889–90, and 31892.
But under the circumstances a serious nuisance remains, 31891.
Probable cost of entire removal of the *Ulva* at Holywood, 31893–4.
Present work of removal efficient as far as it goes, 31895–7.
But the deposit in Colonel McCance's field causes a nuisance, 31897.
Drying of the *Ulva* before removal; practice of the farmers when gathering it, 31899–901.
Drying the *Ulva* by Joint Board would be too costly an operation, 31902–3.
Less inefficiency now in connection with the removal of the *Ulva*, 31904.
Difficulty in getting the *Ulva* removed by contract because of the distribution, etc., of it on the beach, 31905–7.
The nuisance of the *Ulva* has been greatly reduced by the existing work of removal, it might be done away with altogether at a cost not necessarily prohibitive, and there is a probability of considerable improvements being carried out in the methods of gathering the *Ulva*, 31908–9.
Heavy relative contributions of Holywood to the expenses of the Joint Board referred to, 31909–10,

MUSSELS:

Mussels and *Ulva*, *Hawthorne's notes*, pp. 25 and 26.
Large beds of, between the Connswater and Kinnegar *Cutler*, 31208.
Which have been there a very long time, *ib.*, 31209–12.
Great export of, to Scotland in the past from the Lough, *ib.*, 31212–3.
Beds are now probably larger than they were, *ib.*, 31215–7, and 31239.
Export and use of, almost stopped now, *ib*, 31218–21.
Consume both microscopic plants and animals, *ib.*, 31230.
Serve as an attachment for the *Ulva*, *ib.*, 31234.
Lie on top of the mud, *ib.*, 31235.
Preparations made for experimenting on removal of the mussel beds as an alternative to land reclamation; results will shortly be reached, *ib.*, 31306–11.
Results of an experiment in clearing away, no *Ulva* grows except where there is a small patch of, *ib.*, 31312–8.
Mussel clearing at Southend referred to, *ib.*, 31319.
The effect was to remove the mud, *ib.*, 31320–3.
Cleaning away an alternative to land reclamation, *ib.*, 31326.
Premature at present to form any conclusion of the effect of clearing away either in cost or effectiveness, *ib.*, 31327–8.
Large quantity gathered at Carrickfergus, *Kerr*, 31338.
£4 10s. a ton paid for them, *ib.*, 31339.
But those taken are mainly outside the area involved in this inquiry, *Kerr and Cutler*, 31340.

MUSSELS—*continued.*
  Sand not so good an anchorage for *Ulva* as mussels, *Thompson and Kelly*, 31459 (pp. 38 and 39).
  Growth of, at Holywood, since Harbour Commissioners made a cutting in the bank mussels are smaller and more spread over the beach, *Bell*, 31841.

RECLAMATION OF LANDS FROM BELFAST LOUGH:
  Reclamation of slob lands practicable from an engineering point of view, *Harrison* and *Calwell*, 31004.
  No remedy for the nuisance in the Lough would be effective except the complete scavenging of the shores as the *Ulva* is cast up, and the reclamation of the County Down foreshore where it grows, *Cutler*, 31257.
  Reclamation of the foreshore between the Connswater and Kinnegar required at once; cost of, *ib.*, 31258–9.
  Reclamation from Musgrave Channel to Kinnegar could be effected in two years, *ib.*, 31260.
  The matter dredged from the channel could be used for filling in the bank, but is not in itself stiff enough to make the bank, *ib.*, 31261–3.
  Height of bank required about 15 feet, *ib.*, 31264.
  An embankment would be made, which would be gradually filled up with dredged material and rubbish, *ib.*, 31265.
  Line of the embankment would be below low-water line, *ib.*, 31266.
  Harbour Board are favourable to the reclamation in part, *ib.*, 31267.
  Parliamentary powers would probably be necessary for the reclamation, *ib.*, 31268.
  Ground outside the district would be dealt with, *ib.*, 31269.
  Crown property, *ib.*, 31270.
  The reclamation would probably not alter channels or affect navigation, *ib.*, 31271–2.
  Plan proposed increases cost, *ib.*, 31273.
  Two cradge banks would have to be made, *ib.*, 31274.
  Reclaimed land would ultimately be valuable for agricultural purposes, *ib.*, 31277–8.
  (Memorandum handed in by Mr. G. B. Kershaw respecting reclamation and protection of agricultural land, 31287.)
  £1 10s. per acre would not pay for the proposed reclamation, *ib.*, 31287.
  Belfast more favourably situated for reclamation of land than the Humber, Lough Foyle, or Morecambe Bay, *ib.*, 31288.
  Ulva nuisance would be practically done away with by the proposed reclamation, *ib.*, 31289–90.
  Difficulties of the reclamation might come from the Harbour Board or landowners on the shore, *ib.*, 31297.
  Probably no difficulties from the shore landowners, *ib.*, 31298–300.
  Difficulties could probably be met by an arrangement with the Harbour Board, *ib.*, 31301–2.
  Harbour Board would probably reap great benefit from the reclamation, *ib.*, 31303.
  Material to be scoured out of the Lough and the scour itself would probably be reduced in the same proportion, *ib.*, 31304.
  Reclamation might possibly alter the set of the currents in the Lough, *ib.*, 31331.
  Reclamation of large tracts of foreshore suggested as a remedy for the nuisance (Statement), *Thompson and Kelly*, 31459.
  Reclamation of slob-lands would be very expensive, *ib.*, 31558.
  It would be an improvement, but Holywood would suffer, *ib.*, 31559.
  Channels would not be seriously damaged by reclamation of the slob lands, *ib.*, 31562.
  Points for and against the reclamation; details as to, *ib.*, 31563–6.
  Reclamations of slob-lands would lessen scour; particulars as to the scour, *ib.*, 31571–6.
  Under current eats away the sides of the slopes of the channels. The reclamation of 750 acres a commercial rather than an engineering question, *ib.*, 31581–2.

RECLAMATION OF LANDS FROM BELFAST LOUGH—*continued.*
  Some of the matter to be cleared out of the channels might be reduced by reclamation of the slob lands, *ib.*, 31626.
  Reclamation might extend the trouble complained of at Tillysburn to the slob-lands from Kinnegar Point to Cultra, *ib.*, 31627.
  Slight growth of *Ulva* on Holywood bank because of sands shifting in gales of wind: these conditions might continue after reclamation, *ib.*, 31628–9.
  Reclamation on the south side of the Lough would remove the larger part of the area on which the *Ulva* is grown, *ib.*, 31632.
  Reclamation would effect an important improvement but will take some time to carry out: further reclamations of lands referred to, *ib.*, 31633–5.
  Holywood owners might be difficult to deal with, *ib.*, 31637.
  Owners of property concerned, *ib.*, 31638.
  Some of the owners would benefit by the reclamation, *ib.*, 31639–40.
  If the Harbour Board and the Belfast Corporation agree there would probably be no difficulty with some of the owners, *ib.*, 31641.
  Harbour Commissioners would probably not stand in the way of an extensive system of reclamation: injury through want of scour probably not serious: advantage in having deep water up the channel and both sides reclaimed, *Thompson*, 31648–50.
  Reclamation probably a commercial question: should be carried on tentatively, in sections, to see the effect on the scour of the channel, *Kelly*, 31650–1.
  Reasons for, *ib.*, 31652.
  Should not be carried out beyond Tillysburn at first, *ib.*, 31653.
  An agreement between the Harbour Commissioners and Belfast Corporation necessary before the proposed reclamation, Commissioners would probably facilitate matters if a permanent improvement were likely to result, *ib.*, 31654–7.
  Period in which the work might be carried out, *ib.*, 31658–62.
  In the reclamation a bank only would be made, not filled in, *ib.*, 31663–4.
  The land could only be used for grazing till filled up, *ib.*, 31664–5.
  Then would be an annual expenditure for draining the reclaimed land, *ib.*, 31666.
  Doubtful if it would pay to deposit dredged material on the area, *ib.*, 31667–9.
  The land would be of little value unless near the city or harbours, *ib.*, 31670–2.
  Harbour Commissioners only make up land as it is wanted, *ib.*, 31673.
  Reclamation of land at the Kinnegar may throw the nuisance down to Cultra and cause trouble with Holywood foreshore owners, but would not affect Belfast, *ib.*, 31674–80.
  Doubtful whether the scour will be improved by the proposed reclamation, *ib.*, 31683.
  Engineering authority is against extensive reclamations, *ib.*, 31684.
  Reclamation wall will have to be very strong; experiences referred to, *ib.*, 31684–7.
  Reclamation of foreshore would be better than cleaning, *Murdoch*, 31784–6.
  Reclamation should extend from the Kinnegar Point to the Point of the Musgrave Channel at Twin Island, *ib.*, 31787–8.
  Holywood would not bear part of the expense outside their district, *ib.*, 31789–91.
  Doubtful whether Holywood would be benefited by it; *ib.*, 31792–3.
  Reclamation of the foreshore the cure for the trouble in the Lough, *ib.*, 31809.
  Reclamation of the foreshore the best course to adopt, *Bell*, 31848.
  Would minimise the nuisance of the *Ulva*, *ib.*, 31858.

RECLAMATION OF LANDS FROM BELFAST LOUGH—*continued.*
- Embankment of Tillysburn area might have an unsatisfactory effect at Holywood if *Ulva* grows in large quantities below low water mark, but not otherwise, *ib.*, 31878–80.
- Reclamation preferable and cheaper in the end than removal of the *Ulva*, *ib.*, 31887–8.

THOMPSON, ROBERT, M.P., Chairman of the Belfast Harbour Commissioners, and REDFERN KELLY, W., M.I.C.E., Engineer-in-Chief to the Belfast Harbour Commissioners (*Analysis of their Evidence.*)
- Statement handed in, in which the nuisance experienced at times in Belfast Lough is attributed primarily to the improper disposal of Belfast sewage, and, secondarily, to the rapid growth of the *Ulva*, p. 38.
- Sand affords a good anchorage for *Ulva* though not so good as mussels, 31459 (pp. 38–9).
- Nuisance at the Lough is caused by the abundant and vigorous growth of the *Ulva* stimulated by the sewage in the neighbourhood, 31460.
- Harbour Board have had to dredge sewage deposits out of the channels to keep them clear, 31461.
- Details showing inefficiency of the chute; originally provided for carrying much less sewage than there is at present, 31462.
- Belfast population has largely increased without increase for sewage outlet, 31463.
- Belfast main drainage scheme; commenced after 1887, 31464–5.
- Sewage brought by intercepting sewers to outfall works in 1892, 31466.
- The chute came into operation from 1891 to 1893, 31467–9.
- Before then Belfast sewage went into the River Lagan, 31470–1.
- Place of sewage discharge, 31472–3.
- Great increase of Belfast sewage through adoption of water closet system, 31474–5 and 31478.
- Increase in volume of dry weather flow, 31476–7.
- Tanks used for storage purposes and not for sedimentation, 31479–82.
- Constant discharge of sewage a great cause of damage, 31483.
- Statutory requirement as to time of discharge: dependent on the tide, 31484–6.
- Harbour Board not relieved of Connswater sewage by Belfast sewage works, 31487.
- Prospective improvement of the Connswater River, 31488.
- Recent polluting effect of the Connswater River, 31489.
- Lagan River was improved by the Belfast sewage works, 31490.
- Opening of a new channel in the Lough coincided with the commencing of the sewage discharge from the chute, 31491–2.
- Silting up and bursting of the chute, 31493–4.
- Consequent discharge of sewage on the sloblands and Harbour channels, 31495–6.
- Chute completely blocked in 1904, 31497.
- Sewage carried by storm overflows into the docks, 31498–9.
- Still going on, 31500.
- Sewage sludge taken out to sea, but sewage still going through openings in the chute, 31500.
- Through inefficiency of the chute much sewage passes into the Seal Channel, 31501.
- Difficult to determine proportionate amount, 31502.
- Silt several feet deep in the navigable channel, 31503–4.
- Course taken by sewage in the Seal Channel on the ebb, 31505.
- Flood tide washed the sewage over all the channels and docks, 31505.
- Current crossing Victoria Channel from the Twin Seal Island, 31506–7.
- The Musgrave Channel, 31508–9.
- Float experiments, 31510.
- Direction of currents and effect of tide, 31511–2.
- Complaints received in consequence of and action at law caused by sewage being swept by the flood tide over wide areas into docks and works, 31513–4.

THOMPSON, ROBERT, M.P., AND REDFERN KELLY, W., M.I.C.E. (*Analysis of their Evidence*)—*continued.*
- Sewage mud in the Musgrave Channel proved by analyses: effect on the men working in the dredgers, 31515–8.
- Smell of *Ulva* and of sewage mud, 31519–22.
- No *Ulva* where the men on the dredgers were affected at the Seal Channel entrance and north-west side of the Victoria Channel north of West Twin Island, 31523–5.
- No appreciable quantity of *Ulva* dredged up there, 31526–7.
- Water closets connected with the harbour, 31528.
- At Harland and Wolff's yards, 31529.
- Cannot get an easement for intercepting sewer from Belfast Corporation, 31530.
- Water closets for 10,000 men there, 31531–2.
- Sewage discharges into the Abercorn basin and thence to the Victoria Channel, 31533.
- Belfast Corporation at present blocking the drainage scheme for Harland and Wolff's works, 31534.
- Bulk of Belfast sewage, except the sludge taken out to sea, comes down Seal and Musgrave Channels, 31536, 31541.
- Direction of flow of Belfast sewage, 31537.
- Should be sent out to sea, 31538.
- Main body is taken to sea by the sludge steamer, 31539, 31541.
- Chute constantly under repair; very little discharge from end, 31540.
- Harbour Commissioners liable in respect of sewage deposits on their slob property, 31542.
- Main object of Harbour Commissioners is to get the solids out of the sewage, 31543.
- Less dredging required since the sludge has been withdrawn from the sewage, 31545–7.
- Sewage sludge dredged from the Victoria Channel, 31548–9.
- Much storm overflow, 31550.
- Continual dredging required in the Musgrave Channel, 31551.
- Large deposits of crude sewage from Belfast constantly accumulating in the Musgrave Channel, 31552.
- Detrition from the banks would give no trouble by itself, 31553.
- Chute was always imperfect, 31554.
- At present the mouth is practically closed, 31555.
- Currents in the Lough are so slow that it is doubtful if sewage from chute would find its way out to sea, 31556.
- It would tend towards the County Down shore, 31557.
- Reclamation of sloblands would be very expensive, 31558.
- It would be an improvement, but Holywood would suffer: sewage should be discharged at Black Head, thirteen miles away, 31559–61.
- Channels would not be seriously damaged by reclamation of the sloblands, 31562.
- Points for and against the reclamation; details as to, 31563–6.
- Tidal scour useful, details as to dredging, 31567–70.
- Reclamation of the sloblands would lessen the scour: particulars as to scour, 31571–6.
- Pool of Garmoyle; formation of: silting up with sewage sludge, 31576.
- Because the scour has been diverted, 31577.
- Silting up with sewage due to the chute, 31578.
- Land water assists in the scour, but there is not much of it, 31579.
- Dredging only required to move material from side slopes of the channel falling in, and sewage deposits, 31580.
- The under current eats away the sides of the slopes. Reclamation of 750 acres a commercial rather than an engineering question, 31581–2.
- Harbour Commissioners would probably be satisfied if the solids in the sewage were removed and a reasonable amount of purification effected, 31583.
- Doubtful whether growth of *Ulva* would be arrested by the proposed purification, 31584.
- It was growing in Victoria Park in 1869–1870, but not luxuriantly, 31585–6.

THOMPSON, ROBERT, M.P., AND REDFERN KELLY, W., M.I.C.E. (*Analysis of their Evidence*)—*continued.*

Trouble with Belfast sewage due to the fact that the original scheme to store sewage and discharge it during first 3½ hours of ebb in deep water at Whitehouse Roads has not been carried out, 31587–9.

The delivery of the sewage over the West Bank has led to the deposit of its solid parts on the bank and the neighbouring enclosures, etc., 31590.

Rate of the current at different states of the tide in the channels, 31592–7.

Sewage in a slow current would rapidly deposit its heavier solids, 31599.

So that the heavier solids are settled on the sloblands north of the Victoria Channel, 31600.

Uncertain whether lighter suspended matter could get across to the south shore of the Tillysburn area, 31601–2.

Dredgings in the Musgrave Channel suggest that it could, 31603.

Only a small quantity comes down the Connswater, 31604.

Doubtful where the deposits on the Tillysburn banks are brought from, 31605–8.

Much *Ulva* on the Tillysburn banks, 31609–10, and 31614–5.

Drifting *Ulva* at Cultra, etc., 31611–3.

Much decayed vegetable matter resulting from the quantity grown, 31617.

Green *Ulva* disappears in winter, 31618.

High winds and storms will clear away the dead *Ulva* and mud, leaving bare sand, 31619–20.

Ulva will tend to fill up channels, 31621.

Doubtful whether the effect of the reclamation of the sloblands would compensate for loss of scour; an old channel intercepts floating matter, 31622–3.

Slow currents in the channels, 31624–5.

Some of the matter to be cleared out of the channels might be reduced by reclamation of the sloblands, 31626.

Reclamation might extend the trouble complained of at Tillysburn to the sloblands from Kinnegar Point to Cultra, 31627.

Ulva does not grow much on the Holywood bank because of the sands shifting in gales of wind, 31628.

These conditions might continue after reclamation, 31629.

Growth of *Ulva* could be more easily dealt with on a bare shore; advantage would result from clearing the *Ulva* from the Tillysburn area, 31630.

Probably impossible to get rid of the *Ulva* nuisance entirely without sufficient purification of the sewage, 31631.

Reclamation on the south side of the Lough would remove the larger part of the area on which the *Ulva* is grown, 31632.

Reclamation would effect an important improvement but will take some time to carry out: further reclamations of lands referred to, 31633–5.

Holywood owners might be difficult to deal with, 31637.

Owners of property concerned, 31638.

Some of the owners would benefit by the reclamation, 31639–40.

If Harbour Board and Belfast Corporation agree probably no difficulty with some of the owners, 31641.

The withdrawal of 180 tons of sludge a day from the Belfast sewage is shown in improved conditions 31642.

If, in addition to that, the discharge of the sewage were limited to the first three and a half hours of the ebbtide, a new chute were constructed, and the sewage discharge was limited to Whitehouse roads, no difficulty would probably arise with the Harbour Board, *Kelly*, 31643.

This would fulfil statutory requirements, 31644.

The sewage should not be discharged so near Belfast as Whitehouse roads, whether there is a new chute or not, *Thompson*, 31645–6.

The Harbour Commissioners are concerned as custodians of the Harbour on the question as to the effect of action proposed on the growth of *Ulva*. They would probably not stand in the way of an extensive system of reclamation. Probably the injury would not be serious through want of scour. There would be advantage in having deep water up the channel and both sides reclaimed, *Thompson*, 31648–50.

The reclamation will probably be a commercial question. It should be carried on tentatively, in sections, to see the effect on the scour of the channel, *Kelly*, 31650–1.

Reasons for, 31652.

Should not be carried out beyond Tillysburn at first, 31653.

An agreement between the Harbour Commissioners and Belfast Corporation necessary before the proposed reclamation; Commissioners would probably facilitate matters if a permanent improvement were likely to result, 31654–7.

Period in which the work might be carried out, 31658–62.

In the reclamation a bank only would be made, not filled in, 31663–4.

Land could only be used for grazing till made up, 31664–5.

There would be an annual expenditure for drainage of the reclaimed land, 31666.

Doubtful if it would pay to deposit dredged matter on the area, 31667–9.

The land would be of little value unless near the city or harbour, 31670–2.

Harbour Commissioners only make up land as it is wanted, 31673.

Reclamation of land at the Kinnegar may throw the nuisance down to Cultra and cause trouble with Holywood foreshore owners, but would not affect Belfast, 31674–80.

The sewage discharged outside the entrance to Belfast Lough will not damage the Bangor Urban District, 31681.

Doubtful whether the scour will be improved by the proposed reclamation, 31683.

Engineering authority is against extensive reclamations, 31684.

The reclamation wall will have to be very strong; experiences referred to, 31684–7.

All the Belfast sewage should be discharged at Blackhead, *Thompson*, 31688.

Cost might be about £350,000, 31689.

No trouble would be caused at Blackhead, it goes there now by the dredgers, 31690–1.

It might be taken round by the banks in a metal culvert, 31692.

High level pumping would be required, 31695–6.

ULVA LATISSIMA:

No traceable remains of in mud, *Harrison and Calwell*, 30643–4.

Huge beds at low water mouth of the Tillysburn River, *ib.*, 30646.

Evidence of sewage pollution wherever it has been found, *ib.*, 30652.

Luxuriant growth of due to sewage, *ib.*, 30653.

Great increase of at end of the last century and since, *ib.*, 30709–15.

Probably grown in shallow waters of the Lough, *ib.*, 30945–6.

Conditions favourable or otherwise to the growth of, *ib.*, 30949–52 and 31118–30.

In the Victoria Park lake, *ib.*, 30953–9.

Purification of Belfast sewage advisable to show effect on, *ib.*, 30960.

Occasional resemblance of decaying *Ulva* to closet paper, *ib.*, 31056.

Great increase in *Ulva* in the Tillysburn area since its pollution by Belfast sewage, *ib.*, 31118–9.

Growth of increased after construction of purification works, *ib.*, 31121.

Does not flourish where there is a great amount of sewage, *ib.*, 31122–8.

ULVA LATISSIMA—continued.
Anchorage required by, *ib.*, 31129.
Special conditions favour growth of on the Tillysburn bank, *ib.*, 31130.
Belfast Lough is much polluted with it at present, but was not formerly, 31135.
It flourishes in liquids containing ammonia, nitrate, and nitrates, 31135.
Nurseries of, *Cutler*, p. 22.
Growth of, *Hawthorne*, p. 25.
Shellfish and, *Hawthorne*, pp. 25.
Salt water, but not brackish, favourable to growth of, *Hawthorne*, 31147–8.
Brackish water is more suitable for growing than seawater, *Cutler*, 31149–50.
Questionable whether there was very little *Ulva* in the Lough many years ago, *ib.*, 31151.
Experiments in growth of, *ib.*, 31152–3.
The Lagan and Connswater flow over the beds of, *ib.*, 31157–60, 31169.
Not so much on the north side of the Lough, *ib.*, 31167–8.
Ulva and albuminoid ammonia, *ib.*, 31172–4.
Influence of organic matter on the growth of, *Adeney*, 31176.
Professor Letts' experiments respecting the absorption of ammonia by *Ulva* in daylight and darkness, *ib.*, 31177.
May absorb ammonia in darkness but not convert it into tissue, *ib.*, 31177–8.
A considerable part of the nitrogen by which it is nourished is derived from the Lagan River and other tributaries and the rainfall generally, *ib.*, 31183.
The largest quantity grows between the Connswater and Kinnegar, *Hawthorne*, 31207–8.
A great nuisance at Holywood in 1894, *ib.*, 31224.
Methods of attachment to its bed, *Cutler*, 31225–6, 31229.
Nourished by absorption of the dissolved products of fermentation in the mud, *Adeney*, 31227–8.
Difference in character of the mud where it grows and does not grow, *Cutler*, 31229.
Quiet condition of the water at the Tillysburn area favourable to the growth of, *ib.*, 31230–1.
Mussels serve as an attachment for, *ib.*, 31234.
Nuisance in the Lough would have ceased if the *Ulva* had been collected and disposed of, *ib.*, 31244–5.
Farmers have to be paid to cart it away, *ib.*, 31246.
It is a fairly good manure, *ib.*, 31248.
Practically all the *Ulva* is growing in the area it is proposed to reclaim, *ib.*, 31290.
Great quantities floating in the summer, *ib.*, 31291.
When carried from where it grows probably goes out to sea, *ib.*, 31305.
None grows except where there is a small patch of mussels, *ib.*, 31312–8.
Flourishes most when close to sewage solids, not in sewage itself, *Adeney*, 31384–5.
Ulva on the Tillysburn area may derive its nourishment from the Connswater and the Lagan, *Adeney*, 31395.
Nuisance in the Lough partly due to vigorous growth of *Ulva* stimulated by sewage, *Thompson and Kelly*, 31459–60.
Much *Ulva* on the Tillysburn banks, *ib.*, 31609–10, 31614–5.
Drifting *Ulva* at Cultra, *ib.*, 31611–3.
Much decayed vegetable matter resulting from quantity grown, *ib.*, 31617.
Green *Ulva* disappears in winter, *ib.*, 31618.
High winds and storms clear it away, *ib.*, 31619–20.
Tends to fill up channels, *ib.*, 31621.
Does not grow much on the Holywood bank because of the sands shifting in gales of wind, *ib.*, 31628.
Growth of could be more easily dealt with on a bare shore, advantage would result from clearing it from the Tillysburn area. *ib.*, 31630.

ULVA LATISSIMA—continued.
Probably impossible to get rid of it entirely without sufficient purification of sewage, *ib.*, 31631.
No accumulation of *Ulva* on the Holywood shore in 1888 or 1889, *Murdoch*, 31711–2.
Very little near Kinnegar or Holywood at that time, *ib.*, 31713–5.
Very little grows at Holywood, *ib.*, 31736, 31738.
It began to be piled up on the Holywood shore in 1885 and since then in increasing quantities, *ib.*, 31737.
Does not grow on pure sand, *ib.*, 31738.
Holywood council for a few years cleared it off the shore, *ib.*, 31739.
Farmers use it for manure, *ib.*, 31740–1.
It is worse at the Tillysburn area and at Cultra because of the wall there which apparently retains it, *ib.*, 31742–4.
Details as to weight of removed in recent years, *ib.*, 31763.
No smell from *Ulva* if it is carted away fresh, *ib.*, 31766–7.
Too much to clear away, *ib.*, 31769.
Less than half the *Ulva* at Holywood is removed for £1,500 a year, *ib.*, 31770–6.
Practically impossible to get at the rotting masses farther out from the shore at Holywood than is done, *ib.*, 31781–3.
Comes ashore at Holywood in blocks with mud attached to it, *ib.*, 31818–20.
Grew some years ago in the upper reaches of the Lough, but not to the same extent as at present, *Bell*, 31836.
Not so much *Ulva* grew fifteen or twenty years ago at Holywood as at present, *ib.*, 31837–40.
Considerable increase in growth of below low water mark, *ib.*, 31842.
Principally comes ashore in May and June, and a second growth in August and September, *ib.*, 31842–4.
Farmers clear away large quantities in October, *ib.*, 31846.
Alteration of Belfast Main Drainage system in 1887 has caused a larger growth of, *ib.*, 31846.
Effect of the rotting *Ulva* in preventing bathing at Cultra, and its blackening of paint and silver by emanations of sulphuretted hydrogen, *ib.*, 31847.
Growth of, below low water mark (discussion as to), *ib.*, 31849–57.
Ulva at Cultra lying on clean sandy bottom, *ib.*, 31859–62.
Ulva at Garmoyle: probability of growth below low water mark, *ib.*, 31863–70.
Very little grows on the Holywood bank, *ib.*, 31871–3.
Inference from observation respecting growth of below low water mark, *ib.*, 31876–7.
The nuisance at Holywood might be cured by removal of *Ulva* from the beach, *ib.*, 31881–2 and 31885.
Entire removal of from all the banks at Holywood impracticable, *ib.*, 31885–6.
Removal of from the Holywood shore has in effect been successful according to the money spent, *ib.*, 31889–90 and 31892.
Probable cost of entire removal of at Holywood, *ib.*, 31894.
Drying of, before removal: practice of the farmers when removing it, *ib.*, 31899–901.
Drying by the Joint Board would be too costly, *ib.*, 31902–3.
Difficulty of getting *Ulva* removed by contract because of the distribution of it on the beach, *ib.*, 31905–7.
Nuisance of the *Ulva* greatly reduced by the existing work of removal; might be done away with altogether at a cost not necessarily prohibitive; probability of considerable improvement in the methods of gathering it, *ib.*, 31908–9.

APPENDIX II.

REPORT TO THE COMMISSION UPON THE EXAMINATION OF BELFAST LOUGH IN SEPTEMBER, 1909, BY C. C. FRYE AND G. B. KERSHAW.

January, 1910.
[Revised October, 1910.]

In accordance with the instructions of the Commission we visited Belfast and made an extended examination of the Lough and the sloblands, with reference to the growth, development and decay of the seaweed *ulva latissima.**

Our visit began on September 1st, and ended on October 1st, 1909. Throughout this time we were in touch with Sir William Power and Mr. Stafford.

In giving the results of our observations, we may remind the Commission that the development of *ulva latissima* is dependent upon the season, and that the condition of the foreshores as regards accumulation of *ulva* varies according to the strength and direction of the wind. The remarks upon these heads are to be taken as applying particularly to September, 1909.

Our observations comprised the dredging and trawling of the Lough and the exploration of the sloblands.

As a preliminary survey showed that little nuisance from *ulva latissima* existed beyond Grey Point, on the County Down side, and Carrickfergus, on the Antrim side, we confined our attention, in the main, to that part of the Lough which would be enclosed by a line connecting those two points.

I.—Dredging.

The dredge consisted of a bag net, about 2 feet 6 inches deep, attached to a triangular face plate, each side of which was 18 inches long.

With this apparatus some fifty dredgings were made from the mouth of the chute towards the Lighthouse and Carrickfergus, *i.e.*, through the Whitehouse and Folly Roads, and from the Lighthouse and Grey Point inwards to the Twin Islands and the mouth of the River Connswater. Throughout these operations the boat was directed in a zigzag course.

The depth of the water varied from about 1 to 6 fathoms at low tide.

So far as we were able to judge, the bottom of the Lough on both sides of the navigation channel seemed to be composed mainly of clean sand, overlying estuarine clay. In one or two places, as, for instance, outside the Carrickfergus bank, it appeared to be somewhat rocky, while in the Victoria Channel, from No. 7 Buoy to the Twin Islands, and in the Old Channel and the Pool of Garmoyle, from No. 7 Buoy to No. 10 Buoy, and thence to the mouth of the Connswater, there was a thick deposit of black mud.

From those parts of the Lough where the bottom was rocky, a considerable quantity of a large brown seaweed was dredged up. A few small fronds of *ulva latissima* were also found with the brown seaweed. These fronds may have been rooted to the rocks, but our impression was that they were either lying unattached at the bottom or else that they were floating in the water and had been caught as the dredge was lifted.

On the smooth and sandy bottom, off the mouth of the chute, and in the Whitehouse and Folly Roads, there appeared to be very little *ulva latissima*. A few small fronds were occasionally brought up, but, as a rule, the dredge contained only sand and shells.

From the Lighthouse and Grey Point to Holywood Bank, where the bottom was also sandy, a fair quantity of *ulva* was brought up every time the dredge was lifted, the number and size of the fronds increasing as the Bank was approached.

The number of fronds brought up in this part of the Lough also increased as the County Down shore was approached. Near the Victoria Channel (Buoys Nos. 1, 2, 3 and 4) only isolated fronds were found.

The *ulva* fronds found in the area just mentioned were invariably small in size and had jagged edges. As they resembled the fronds seen floating in the water which covered the area, and as *ulva* was never seen growing on sand, we concluded that they had been deposited there.

It is to be noted that many more *ulva* fronds were brought up from the sand on this side of the Lough than on the Antrim side.

From the muddy bottom in the Victoria and Musgrave Channels, *i.e.*, from No. 7 Buoy towards the mouth of the Connswater, and especially in the Musgrave Channel, a considerable number of *ulva* fronds were usually brought up with mud every time the dredge was lifted. The number and size of the fronds increased as the Tillysburn and Connswater banks were approached.

II.—Trawling.

The trawl used was a bag net, about 6 feet deep, attached to an eliptical iron ring which had extreme dimensions of 3 feet and 18 inches. The meshes of the net were 1 inch square. The mouth of the trawl was kept a given distance below the surface of the water by means of weights and buoys attached to the iron ring.

The trawling was carried out on the same general plan as the dredging, the position of the trawl, as regards depth, being varied from time to time. As a rule, the trawl was at a depth of 3 to 6 feet, but at times it was sunk to 15 feet or more.

The results were very similar to those obtained with the dredge, the only difference being that a considerable number of small fragments of *ulva* frond were found floating beyond the Lighthouse towards the open sea.

Very few fronds of *ulva* were caught in the trawl on the Antrim side of the navigation channel, while on the County Down side the trawl was seldom brought in without a few small fronds entangled in its meshes.

On the County Down side of the Navigation Channel, from Grey Point and the Lighthouse towards Belfast, the number and size of the fronds increased as the shore and the point of the Kinnegar were approached.

A considerable quantity of *ulva* was caught in the Navigation and Old Channels, from No. 7 Buoy towards Belfast, and the number and size of the fronds increased as the Tillysburn and Connswater banks were approached.

Generally speaking, the fronds were most abundant within 6 feet or so of the surface.

It was noticed that, in the comparatively open water from the Lighthouse towards the sea, the *ulva* fronds were not at all evenly distributed, being usually met with as more or less separate assemblages extended in long lines.

III.—Exploration of the Foreshores and the Sloblands.

(1) *Foreshores.**

The foreshores on both sides of the Lough were examined carefully. On the Antrim side, the examination extended from Belfast to White Head, and, on the County Down Side, from Belfast to Grey Point.

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* Throughout this Report the term *ulva latissima* is used in a general sense. It is intended to include not only *ulva latissima* itself, but also other green seaweeds of similar appearance, such as *monostroma grevillii*. Reference should be made to Mr. Cotton's report (Appendix IV.), where it will be seen that the bulk of green seaweed in Belfast Lough is *ulva latissima*.

* As regards the inner portion of Belfast Lough, where great areas of slob and sand are uncovered at low tide, the term Foreshore is used in a particular sense to mean beach or strand near high-water mark. Outside Cultra, on the County Down side, and Macedon Point, on the Antrim side, the term is used ordinarily, and includes the whole shore between high and low-water marks.

(a) *Attached Ulva.*—We found *ulva* growing freely, but not in excessive quantities, wherever the shore was rocky. As a rule, it was rooted to the under ledges of the rocks.

All along both sides of the Lough isolated fronds were seen attached to mussels, broken shells and rough stones.

The quantity of growing *ulva* appeared to diminish on both sides as we proceeded seawards from Belfast, but this diminution was by no means regular, the greatest number of fronds being always found where the shore was rocky and to some extent protected from wave action.

Enteromorpha intestinalis appeared to be as plentiful as *ulva* along both foreshores; at the mouths of all fresh water streams it was usually growing in profusion.

(b) *Detached Ulva.*—There were great quantities of detached *ulva* lying on both foreshores of the Lough.

The deposits were always greatest in bays, protected corners, creeks and places where, owing to banks and shoals, the tide runs are slack. It was, thus, obvious that the influences which most affected the deposit of floating *ulva* were wind and tide.

So far as the drift of single loose fronds is concerned, the effect of the tide is probably the greater of the two, for fronds of this kind were observed to float, as a rule, below the surface of the water.

On the other hand, wind has a very marked effect on the drift of floating fronds which have previously been cast up on the shore and so become partially dried and matted together. *Ulva* fronds in this condition retain air bubbles beneath them, and for this reason often float on the surface of the water. On several occasions we observed large floating masses of matted *ulva* being driven by the wind at a considerable speed across the Lough. We noticed also that a strong wind blowing off shore was sufficient to remove a large portion of the deposited *ulva* from the shore at high tide and to carry it either seawards or to a totally different part of the Lough.

On the Antrim shore there was much less deposit of *ulva* than on the County Down shore, and offensive decomposition was taking place only in a few specially protected places, such as the corner made by the main drainage reclamation bank with the Antrim shore proper, and in freshwater creeks. In such places there was a serious local nuisance.

In a small fresh-water creek at Lower White House, extending to the bridge in the centre of the village, there was a nuisance which could only be described as abominable. A screen or a tide weir across the mouth of this creek would have an immediate effect in preventing the access of *ulva*. Crude sewage is discharged into this creek amongst the decomposing *ulva*.

Beyond Macedon Point, towards Carrickfergus, the deposits of *ulva* were much smaller. At Carrickfergus and beyond we could observe no nuisance.

On the County Down side the shore was thickly strewn with detached *ulva* from Sydenham almost to Grey Point. In several protected bays it was lying a foot or even 18 inches deep, and here, as a rule, there was an abominable nuisance owing to the decomposition of the wet weed. The worst nuisance was experienced from Sydenham to the Kinnegar, but there was a serious nuisance all along the shore, and notably in a bay close to the landing stage at Cultra.

At the time of our visit, the *ulva* was being carted by the staff of the Joint Foreshore Board from the bay at Cultra, and, although the nuisance was not prevented by this operation, it was undoubtedly diminished. The *ulva* was being spread over fields as a manure.

Between the Kinnegar and Tillysburn, the work of the same authority consisted in the removal of the partially dried weed from the foreshore by means of trucks, and the dumping of this on to a large heap, just inland, at a point close to the Tillysburn river. These operations seemed to us to be of little use for two reasons:—

(1) Because the nuisance, which was mainly derived from decomposing *ulva* lying some little distance out from the high water mark was not much affected by the removal of the shore weed, and

(2) Because of a very serious nuisance which arose from the heap of *ulva* in the field.

As to the place or places of origin of the *ulva* which is deposited on the shores of the Lough, we propose to refer later, but there is one point which should be mentioned here.

This relates to the conditions under which *ulva latissima* undergoes offensive decomposition. We would suggest that this is a subject which requires investigation, and would also refer to the remarks of Dr. Letts upon the same point.* It appears to us that somewhat special conditions are necessary if offensive decomposition is to take place. So far as our observations go, the fronds need to be closely matted together, and the mass must remain in this state for a considerable time, either completely submerged in pools of water, or else subject to intermittent submersion.

Single fronds do not appear to undergo offensive decomposition under any ordinary conditions, nor do masses of matted fronds, when these are deposited in positions which allow of good drainage.

(2) *Sloblands.*

There are two large areas of slob or muddy land uncovered at low tide in Belfast Lough, one on the Antrim side and the other on the County Down side.

(a) *Antrim side.*—The slobland on the Antrim side is in the form of a broad irregular crescent, extending on its concave side from No. 9 Buoy almost to Macedon Point, and bounded on its convex side by the reclamation banks of the Main Drainage Works, and by the Antrim shore from the end of the west reclamation bank to Macedon Point.

Part of this area is slob proper, or soft mud, and part is clean and fairly hard sand. Lines drawn from the point of the West Twin Island to the mouth of the chute, and from the mouth of the chute to Green Castle station, would roughly enclose the slob proper and serve as an inside boundary to the sand, that is to say, they would divide the mud from the sand. Almost midway between the mouth of the chute and Green Castle station there are hard mussel banks.

We explored this area very carefully, paying particular attention to the slob proper.

That part of the area which would be enclosed in the way indicated, *i.e.*, the slob proper, is composed of a rather soft deposit of estuarine clay, sand and mud. Owing to its softness, it can only be crossed with difficulty and some danger.

Speaking generally, the surface of this slob is flat, with a gradual rise to the shore and the reclamation banks. On the whole, therefore, the tide rises and falls straight across the Antrim slob, covering it to a depth of from 3 to 6 feet.

Over part of the slobland on this side of the Lough, however, the tide flows and ebbs in a way which deserves special mention.

This area is bounded on the north-east by the West bank, on the south-east and south by the West Twin Island and the east reclamation bank, and on the south-west by the main drainage banks. On the west and north-west it extends rather beyond the chute.

It is largely overflowed and drained through a channel, called the Seal Channel, which runs, first in a north-easterly direction along the east bank of the Main Drainage Works, and then turns almost at a right angle towards the point of the West Twin Island.

On the ebb tide, the Seal Channel drains the area of slobland mentioned above, the timber ponds at the back of the Main Drainage Works, and, in addition, carries the water of the Milewater river.

This channel is especially important in connection with the discharge of sewage from the Main Drainage Works because, soon after the ebb has begun, it carries directly and rapidly to the main navigation channel:—

(1) any leakage of sewage from the inner half of the chute,

(2) the contact bed effluent, and,

(3) partially settled storm sewage.

At the time of our visit the area of slob enclosed by the west bank was practically free from "attached" fronds of *ulva latissima*. There was, in fact, practically nothing to which *ulva* could be attached, beyond the broken shells on the west bank itself, and these are subject to considerable wave action, both naturally and through the passing of vessels up and down the navigation channel. There were very few mussels on the area.

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* Royal Commission on Sewage Disposal, Fifth Report, Appendix VI., p. 142..

It was noticed that the water over this area was at high tide visibly polluted with sewage.

There was a large quantity of detached *ulva* lying on the shore of the West Twin Island.

On the west side of the chute similar conditions prevailed generally, but here there were isolated fronds, attached, in almost every case, to a mussel, not by the root of the *ulva*, but by the threads of the mussel.* A mussel and an *ulva* frond per square yard would give an idea of the extent of the growth near the chute, while over against the Antrim shore, a mussel and an *ulva* frond every ten square yards would be nearer the mark.

In the middle of this slobland, however, and protected by the mussel banks mentioned previously, the ground is rather firmer, and here there was a large quantity of *ulva* attached by mussels, growing along with *Zostera Marina*, or sea grass. This patch of *ulva* had an area of about ten acres.

A fair quantity of *ulva* was also growing on the banks of mussels farther out.

Taking the Antrim slobland as a whole, there was very little growth of *ulva* as compared with the County Down slob. At a rough guess we should say that the quantity did not represent a hundredth part of that on the County Down slob. The following points seem to be worth consideration in connection with this comparatively small development of *ulva* on the Antrim slob :—

(1) The pollution of the water by sewage is very considerable in the neighbourhood of the chute and the Main Drainage Works.

(2) The Antrim slobland is lower than the County Down slob and much flatter. It is reasonable, therefore, to suppose that, in addition to being covered each tide for a longer time, the slob is exposed to greater wave and wind action, and is subject also generally to a stronger scour by the tides.

In this connection the Commission may be reminded that the main growth of *ulva* on the Antrim side occurs in a protected position and some distance from the chute.

(3) Except on the outer banks, referred to previously, where wave and tide action must be considerable, there is a very much smaller development of mussels on the Antrim than on the County Down slob.

(b) *County Down side.*—On the County Down side of the Lough a large area of land is also uncovered at low tide. This area extends from the mouth of the Connswater to Cooper's Bay, a distance of approximately three and one-third miles. In width it varies from half a mile to a mile and a quarter, the average being about three quarters of a mile. We explored it thoroughly on foot.

By far the greater part of this area is composed of sand superimposed on the estuarine clay of the Lough. The depth of the sand layer varies considerably. Speaking generally, it diminishes as the mouth of the Connswater is approached.

At Cooper's Bay and on the Holywood bank the sand is fairly deep and forms a firm and strong crust to the clay.

Between the Kinnegar and the Connswater, however, it does not appear to average more than an inch or two in depth, and there are many places in this portion of the area, *i.e.*, in channels and streams, where the clay is bared. When the sand crust is very thin, walking is attended with considerable difficulty, owing to the softness of the clay beneath.

On the outer half of the area, between the Connswater and Holywood, the sand crust is more or less covered with a deposit of soft black mud, which emits a strong smell of sulphuretted hydrogen when disturbed.

In general, the deposit of mud is very uneven, and over the greater part of this outer area it takes the form of hummocks and ridges, from 6 inches to 3 feet in height, which are covered with mussels.

This ridge formation is doubtless due to the mussels; the mud itself would rapidly be washed away if it were not held together and protected by the mussels.

At the mouth of the Connswater, however, there is a large area completely covered with the mud to a depth of from 6 inches to 3 feet or more. This area is also coated with mussels.

The mussels on the outer ridges and hummocks of the Tillysburn banks, being subject to considerable wave action, were clean, but those on the inner hummocks and on the mud at the mouth of the Connswater were, as a rule, so thickly covered with fronds of *ulva latissima* as to be hidden from view.

As showing the abundance of the growth on some of these hummocks, we may state that in several places over 100 lbs. of wet *ulva* were lifted from a square yard of surface. The fronds were mostly large, but they varied in size from a square yard, or more, to 3 or 4 square inches. On lifting a frond of *ulva* from such a position we found, almost without exception, that it was attached to a mussel or mussels by the mussel threads, and not by any root of its own.

Ulva fronds attached by their own roots to mussel shells were indeed fairly common, but their number was insignificant compared with the number of fronds held by mussel threads.

Owing to the uneven distribution of the mussel hummocks, it was exceedingly difficult to estimate with any degree of accuracy the quantity of *ulva latissima* thus growing on the Connswater and Tillysburn banks; but that it was more than sufficient to account for the quantity of detached *ulva* fronds lying on both foreshores of the Lough was clearly evident.

The sloblands on the County Down side of the Lough are much more uneven as regards levels than those of the Antrim side, and as this seems to have an important bearing on the growth of the *ulva* attached to the mussels, we think it desirable to give a broad idea of the general physical features.

As there is little "attached" growth of *ulva* beyond the point of the Kinnegar, only the area between this point and the mouth of the Connswater need be taken into account.

In the first instance it would seem that, on the whole, the general level of the slob on the County Down side is higher than that of the slob on the Antrim side.

Close to the shore against Tillysburn Station, on the County Down Railway, the slob level declines shorewards and towards Sydenham Station, and from this point a channel or gut leads along the shore to Sydenham station, thence along the Victoria Park reclamation bank, across the mouth of the Connswater, to the Musgrave Channel. This channel is called the Silver Stream. For the most part it is deep as well as narrow, and the tides ebb and flow through it with considerable force.

Just outside the bend of the Silver Stream at Sydenham Station, a high and firm ridge rises and extends in the form of a crescent as far as the Old Channel at the side of No. 10 Buoy. Inside this bank and skirted south and west by the Silver Stream and the Connswater river is the comparatively flat area of thick mud previously mentioned. Except for one large circular depression, this muddy area also stands rather high and is only covered as the tide approaches high water. The Connswater river and the Silver Stream then overflow the whole of the area in question, covering it very slowly.

Owing to its peculiar position, therefore, this area of mud at the mouth of the Connswater is not only protected against wave action, but it is also subject to very gentle tidal currents. The water of the polluted Connswater river would pass over it at or near high tide, but not when the current of the Silver Stream was strong, whether on the flow or on the ebb.

The Silver Stream also has the effect of carrying on the flood the brackish water of the Connswater river, the water from the Musgrave Channel, and possibly also a portion of the waters of the Lagan and the Seal Channel, right round on to the back of the Tillysburn bank as far as Tillysburn Station.

A short distance to the north-east of Tillysburn Station a small fresh water stream, called the Tillysburn, finds its way on to the foreshore. When the Tillysburn slob is dry, *i.e.*, before half ebb, this stream continues its course in a channel, which it has eroded in the clay, and which at the same time serves to drain the slob on both sides of its banks. At low tide this channel discharges these mixed waters practically in the Pool of Garmoyle. On both sides of this Tillysburn channel a number of subsidiary channels or guts drain to it on the ebb; one channel, for instance, beginning close to where the Silver Stream starts, and another, on the opposite side, commencing at a similar high point about a quarter of a mile in the direction of the Kinnegar and near the shore.

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* This is a point which has already been referred to by Dr. Letts in a Memorandum sent in to the Commission early in 1909.

When the tide has receded from the banks, however, the main body of salt water draining thenceforward into the Tillysburn channel comes from a long and somewhat narrow depression, which extends from about half to three-quarters of a mile north-west of Tillysburn station, across the Tillysburn, almost to the Kinnegar.

Owing, mainly, to the fact that it is very flat, but also because of the small mussel hummocks which lie in it and give anchorage to immense quantities of *ulva*, this depression never became dry at the time of our visit, and had, therefore, the usual appearance of a long pool divided into two unequal lengths by the channel of the Tillysburn river.

The section of this long pool on the west of the Tillysburn channel is drained partly by the Tillysburn itself, and partly by a gut which serves a large area of the slobland lying between the Connswater ridge and the Tillysburn channel.

It will be seen that these two pools on either side of the Tillysburn must fill and empty very gradually as the tide rises and falls. Further, they are well protected from wave action by the high mussel hummocks which fringe the outer side of the Tillysburn banks. When these hummocks are covered, the water in the pools has become 3 or 4 feet deep.

There are other and smaller guts which serve as channels for the water flowing on to and ebbing from the banks, but only one more need be mentioned. This gut begins close to the shore, about a quarter of a mile north-east of the Tillysburn river, and follows the course of the shore round to the point of the Kinnegar. It is comparatively shallow and is completely uncovered before half ebb.

By means of this channel a considerable portion of the Holywood end of the Tillysburn bank is in turn fed and drained. The sewage effluent from the Holywood barracks is delivered into it, and is thus carried, as the tide approaches high water, on to the banks. It is possible, too, that some of the sewage discharged at Holywood may find its way on to the banks by the same means.

Apart, therefore, from the sewage which is discharged at the mouth of the chute, it is clear that on the flow of the tide a considerable quantity of sewage and sewage polluted river water does find its way over the Connswater and Tillysburn mussel and *ulva* beds.

The Silver Stream carries on the flood the Sydenham sewage, the water of the Connswater, and some at least of the water from the Lagan and the Seal channel, on to the Connswater end of the Tillysburn bank, while the Kinnegar channel carries the sewage effluent from the barracks and possibly some Holywood sewage on to the Holywood end. The Tillysburn river water, which is polluted with drainage from dumped *ulva*, finds its way on to the centre of the bank as the tide rises.

IV.—The Black Mud.

It will be seen that, at the time of our visit, immense quantities of *ulva* were growing on the County Down slobland, that by far the greater part of this *ulva* was anchored by mussels, and that the greatest development of the weed was always in localities specially protected as regards tidal current and wind action.

Over a considerable area in the neighbourhood of the chute the Antrim slob was observed to be thickly covered with a greyish brown deposit. That this deposit was largely sewage matter there could be no manner of doubt. It had the greasy appearance and the characteristic bitter smell of sewage sludge.

The mixture of sand and clay immediately beneath it was black and had a strong septic smell.

This kind of mud was not seen more than a quarter of a mile from the chute in any direction.

In the circumscribed patch of *ulva* on the Antrim slob, small rounded hummocks of mud were observed. These hummocks had the light grey appearance of the estuarine clay, but, on disturbing them, they were found to be composed of black gelatinous mud, very smooth to the touch, and more adherent than most sewage sludge. The absence of large particles of grit was especially noticeable. This mud gave out a strong smell of sulphuretted hydrogen when disturbed.

Similar mud was found with heaps of rotting *ulva* in various corners and creeks on this side of the Lough.

On the County Down slobland the same kind of gelatinous mud was also present and in very much greater quantities. The mussel hummocks mentioned previously were largely composed of it, and it occurred in other positions which will be mentioned shortly.

On elutriating this gelatinous mud with water we found that it was mainly composed of small pieces of *ulva*, mostly black, but some of which retained their original green colour. There was also a good deal of finely divided black matter.

It was obvious, in fact, that this mud consisted largely of *ulva latissima* in all stages of decomposition; and hence the question arose :—

If such black mud is derived from *ulva*, at what places on or near the Tillysburn bank should it be found most abundantly? In the light of what has been said as regards the configuration of the banks, the answer would have to be :—

(1) In the protected places where *ulva* is growing luxuriantly.

(2) In the deep water at the mouths of the various streams which drain the *ulva* beds and carry detached fronds away; as for instance, in the Musgrave channel, the Pool of Garmoyle, and probably for some distance along the main navigation channel.

(3) On those parts of the banks where the waters of the rising tide meet and deposit detached *ulva* fronds.

It was in these places that the chief deposits of this black mud were actually found.

It cannot for one moment be suggested that there is no sewage-derived mud in the Navigation channel and in the Pool of Garmoyle. Much storm sewage and leakage from the chute is carried directly into the Navigation channel by means of the Seal channel, and the crude sewage of the ships in the harbour comes down the river Lagan, but that much of the black mad in these channels is derived from *ulva*, there can, we think, be little doubt.

Except off Holywood, Sydenham and Lower Whitehouse where crude sewage is discharged on to the shore, in the river Lagan, in the Seal channel and in the neighbourhood of the chute, we saw no matter floating or deposited which, by its appearance, could be said at once to be solid sewage matter.

V.—Float Experiments.

From their own observations at Belfast, as well as from what has been recorded in this report, the Commission will probably be satisfied as to the position of what may be called the main developing ground for *ulva* in Belfast Lough.

In our opinion, there was in September, 1909, more than sufficient growing *ulva* on the County Down slob to account for the nuisance along the foreshores, while our dredging and trawling operations gave no single indication of the existence of an extensive developing ground in any permanently submerged part of the Lough.

The results obtained by Professor Letts in his experiments upon the development of *ulva* in polluted water led us to expect a large growth of the weed in the track of polluted water from the mouth of the chute and especially on the Antrim slobland near the main drainage works.

We found, however, that the greatest development of *ulva* occurred in localities far removed from the Belfast outfalls, always where there was suitable anchorage for the weed in the form of mussels, and where there was special protection of slob-land from wave and tide action.

It seemed to us more than probable, therefore, that if the Belfast sewage was one of the main factors in the great development of *ulva* on the Tillysburn and Connswater banks, the water of the Inner Lough would be found to be widely and generally polluted, and that this water flowing over the County Down slobland in all directions carried the sewage to the *ulva* in a very diluted condition.*

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* This theory has since been shown to be correct (cf. Report by Professor Letts and E. H. Richards, Appendix III.)

In order to ascertain how far the accumulation of detached *ulva* on the shores was due to the drifting thither of fronds grown on the County Down and Antrim sloblands we carried out some float experiments.

It was thought that these experiments might also show whether Belfast sewage was carried across the navigation channel to the County Down sloblands.

Desiring in these experiments to imitate the detached *ulva* fronds as far as possible, we devised a form of float consisting of a small piece of calico attached by a short length 6 inches) of string to a cork which kept the submerged piece of calico from sinking.

On September 17th, 1909, at about low tide, 150 floats of white calico were placed on the outer part of the Tillysburn bank opposite to and about half a mile from Tillysburn railway station. Shortly afterwards, 150 floats of red calico were distributed over a portion of the Connswater bank.

In from one to ten days, 97 of these floats were recovered (56 white and 41 red), all on the County Down shore between Sydenham and Rockport. The largest number of them was found at or near Cultra.

On the following day, shortly after high water, 150 rectangular floats of blue colour were put into the water close to the mouth of the chute. Of these only twelve were recovered in from three to nine days, all on the County Down shore.

On September 29th, 1909, 150 triangular calico floats of red colour were put in the current of the Seal Channel at about *half ebb*, and on the same day 200 white triangular floats were also placed in the water about a quarter of a mile seawards from the mouth of the chute at *low water*.

In from one to nine days fourteen floats only were recovered on the County Down shore, six white and four red, and but four white on the Antrim shore.

It is of interest to note that the floats placed in the Seal Channel at half ebb were carried by the current into the Navigation Channel within a very few minutes. A few hours afterwards they were seen extended in a long line from the Pool of Garmoyle to the Whitehouse Roads beyond No. 7 Buoy.

No doubt these experiments would have to be repeated several times before any very definite conclusions could be based upon them. In all probability some of the floats after being washed ashore became covered with *ulva* and so escaped notice, while others which may have been ashore for some days may then have been uncovered by the action of the tide.

So far as they go, however, and under the conditions prevailing at the time they were made, the experiments seem to indicate :—

(1) That the *ulva* fronds deposited on the County Down shore are derived mainly from the growths on the Tillysburn and Connswater banks.

(2) That, as the great majority of the floats started off the mouth of the chute and in the Seal Channel were never recovered, the tendency of the drift on this, the Antrim, side of the Navigation Channel is seaward rather than towards either shore.

(3) That *ulva* fronds* from the Antrim side of the Navigation Channel, as also sewage in the water off the mouth of the chute or in the Seal Channel, may be carried across to the County Down shore, but only after considerable lapse of time, and, so far as sewage is concerned, after large dilution.

The experiments upon the destruction of the *ulva* with copper sulphate and other chemicals are dealt with in another report.

Before concluding this report, we must acknowledge the invaluable help rendered to us on behalf of the Commission by Professor E. A. Letts and Mr. H. A. Cutler, M.Inst.C.E., City Surveyor of Belfast. Professor Letts gave us the full benefit of his special experience, and Mr. Cutler lent us his motor boat and supplied us with all the apparatus and materials which were required for our work.

Our thanks are also due to Mr. N. F. J. Napier, M.E.R.U.I., City Surveyor's Department, and Mr. McCall, of the Main Drainage Works. We are particularly indebted also to Messrs. John Duke, Beattie Kingham and William Moore, of the Main Drainage Works. Messrs. Duke and Kingham acted as our guides on the sloblands, and the value of their services could not be overestimated.

COLIN C. FRYE.
G. BERTRAM KERSHAW.

October, 1910.

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* We refer here to loose separated fronds, not to masses of matted fronds. The latter may be driven across the Lough in a comparatively short time when strong winds prevail.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

APPENDIX III.

REPORT BY PROFESSOR E. A. LETTS AND MR. ERIC H. RICHARDS ON GREEN SEAWEEDS (AND ESPECIALLY *ULVA LATISSIMA*) IN RELATION TO THE POLLUTION OF THE WATERS IN WHICH THEY OCCUR.

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1.—INTRODUCTION.

While a fairly full account of the investigations made on this subject by one of us (either alone or in collaboration with others) has appeared in Appendix VI. to the Commission's Fifth Report (pp. 139–168) before the Commission decided to take up the question as being a general one and within the scope of their reference, it seems advisable to give a brief summary of the work which had been done up to that time (1909).

It originated in observations regarding a serious effluvium nuisance which had occurred for many years in Belfast Lough.

So serious did the nuisance become that the inhabitants of the districts where it was most acute, approached the city authorities on the matter, and eventually in 1899 those authorities were required by Act of Parliament to purify the sewage, the scheme of treatment and the method of putting the same into operation being subject to the approval of the Local Government Board for Ireland.

Meanwhile it had been established by observation or experiment that:—

(1) The nuisance could be referred entirely to rotting green seaweeds.

(2) That the chief of these was *Ulva latissima*.

(3) That when this weed decays (under anäerobic conditions) it suffers two distinct but consecutive fermentative changes, in the first of which fatty acids (mainly propionic) are produced, while later the sulphates present either in the tissues of the weed or in the sea-water, are reduced to sulphides with eventual evolution of sulphuretted hydrogen.

Regarding the connection of green seaweeds appearing in a given locality in quantity and the pollution of the water there occurring, the evidence was carefully collected and examined and was found to be in four independent directions, as follows:—

(1) *The high proportion of nitrogen present in the tissues of Ulva latissima*, in which respect the seaweed resembled an animal rather than a vegetable product.*

(2) *The avidity with which certain green seaweeds (and especially Ulva) absorb inorganic compounds of nitrogen such as ammonia and nitrates.*

Numerous laboratory experiments proved this to be the case, ammonia being absorbed more rapidly than nitrates and apparently in accordance with a definite law, namely, that the rate of absorption is constantly proportional to the concentration of the ammonium salt present. The actual amount of ammonia absorbed was often considerable: thus, in one experiment a piece of *Ulva* having an area of 90–100 square inches absorbed 0·0364 grams of nitrogen as ammonium chloride in 24 hours.

It may also be mentioned that it was experimentally proved that *Ulva* cannot absorb such albuminoid matters as occur in polluted seawater.

(3) *An examination of certain localities in which the seaweeds occur in abundance compared with others where the physical conditions are similar but from which the seaweeds are virtually absent.*

Attention was specially drawn to the following: Belfast Lough (polluted) with abundance of *Ulva* and Strangford Lough (very slightly polluted) with scarcely any. Dublin Bay divided by walls for navigation purposes into two portions, the northern portion or harbour (polluted) where plenty of *Ulva* occurs, and the southern portion (unpolluted) until its seaward extremity is reached. *Ulva* is virtually absent from this portion except near Kingstown where it occurs abundantly in the neighbourhood of a sewage outfall of some size.

A third example may be mentioned which came under the personal observation of one of us, namely the town of Lerici near Spezzia. Here the harbour is highly polluted and contains abundance of *Ulva*, while none was seen along the coast outside.

(4) *The spontaneous appearance and growth of certain green seaweeds in a sewage effluent at the experimental purification works in Belfast.**

A small experimental tank with double contact beds, the effluent from which flowed into a pond, had been installed at the Belfast Outfall Works. In the spring of 1902 green growths appeared in the pond which were identified by a botanist to whom they were submitted as *Enteromorpha compressa*, while later in the year *E. intestinalis* and *Ulva latissima* appeared in quantity.

The Belfast sewage is highly saline (containing at times as much as 1 part per 1,000 of chlorine) and undoubtedly water makes its way from the tidal river Lagan into one of the main sewers.

It is probable therefore that the spores of the seaweeds were thus introduced into the sewage, but it is highly remarkable and significant that they should germinate and develop luxuriantly in the effluent. †

Other observations were made regarding *Ulva* such as that it is probably the agent employed by Nature for purifying foul seawater, absorbing ammonia (the chief nitrogenous product of putrefaction) on the one hand, while liberating abundance of oxygen on the other.

Also that its vitality is remarkable, for it may be starved for long periods, cut into pieces, and otherwise maltreated and yet continue to grow luxuriantly when afterwards placed under favourable conditions.

Indeed, a method was suggested for testing the extent of its growth in different liquids by cutting it into pieces of the same area and observing the increase in this factor when placed in the liquids in question and that method was found to work well.

It ought also to be mentioned that one of us had been retained by the Belfast Corporation to experiment and report upon the most suitable scheme of sewage purification for Belfast, and the effects of that scheme on the Lough (mainly in relation to abatement of the *Ulva* nuisance)—a scheme of purification being made obligatory under the Act of Parliament of 1899. The investigations were continued for several years during which three reports were presented, and in the last of them a scheme of purification was recommended based on the elimination of nitrogen from the sewage as far as possible, in the form of nitrogen gas (*see* the Appendix already quoted, pp. 182–193).

Further, it was also suggested by one of us that efficient reclamation of the doblands of Belfast Lough would entirely prevent the nuisance from the rotting seaweeds.

The Commission having decided to take the matter up, a conference of its officers was held in May, 1909, at which a provisional programme of the further investigations considered to be necessary was drawn up. This was submitted to the Commission and approved of, after some of its members had made certain valuable suggestions.

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* In the table on p. 153 of Appendix VI. to the Fifth Report, two determinations of nitrogen in *Ulva* (dry) are given: one of a sample from Belfast Lough containing 6·18 per cent., and one of a weed exactly like *Ulva* in appearance, and which was identified as that seaweed by a botanist to whom the specimen was submitted. It had appeared spontaneously, and grew in large quantities on one of the experimental contact beds at Belfast, and was found to have the remarkable nitrogen content of 8·94 per cent. Eventually, however, the Kew authorities identified it as *Praseola crispa*.

On p. 148 of the same Appendix other determinations of nitrogen in green seaweeds are given, and the opinion is expressed that the nitrogen content increases with the pollution of the water in which the seaweeds occur, an opinion which subsequent investigations have amply confirmed.

* *See* previous footnote relative to the occurrence of another growth which occurred on some contact beds at the same works, and was at first taken to be *Ulva*, but was subsequently found to be *Praseola crispa*.

† A fifth piece of evidence may be mentioned as specially referring to Belfast, viz., that according to a reliable authority the vegetation in the upper reaches of Belfast Lough consisted some fifty to sixty years ago mainly, if not entirely, of sea grass (*Zostera marina*), and that green seaweeds of the type of *Enteromorpha*, or *Ulva*, were virtually absent.

It may be further stated that one of us has been in Belfast for thirty-one years, and there can be no question whatever from his observations that *Ulva* has enormously increased in quantity during that period.

The programme in question has been carried out as far as time has permitted, with certain modifications and additions which seemed necessary as the work proceeded. A list of the different lines on which the investigation has been carried out will be found in the Table of Contents.

We wish to say that while we have done our utmost to elucidate the different problems presented to us, the time at our disposal has been entirely too short to arrive at absolutely final conclusions in many cases: that we have often been confronted with contradictory results for which there was no immediate explanation, while in many cases the number of experiments we were able to make on a given point was totally insufficient, and that new and promising methods of investigation at times presented themselves, too late for us to carry them on for a sufficiently long period.

In short, we have felt, with increasing force as our investigations proceeded, that we were but on the threshold of a work which it would take many years to bring to a satisfactory and definite conclusion.

We have received valuable assistance from time to time from several sources, which we should like to use this opportunity for acknowledging. Throughout the whole course of our work the city authorities have done their utmost to further the investigations and in this connection we are under special obligations to the City Surveyor, Mr. H. A. Cutler, M.Inst.C.E., and Mr. N. F. J. Napier, M.E.R.U.I., who has charge of the pumping station (where a number of our experiments were performed).

Mr. Charles Blakiston Houston gave us valuable assistance in examining the conditions obtaining in Strangford Lough and in collecting various samples of water seaweeds and mud for analysis, and Mr. D. C. Kemp, local manager of the Midland Railway Company's steamers most kindly arranged for the collection of a number of samples of water from the Irish Channel by the officers of the Company's boats running between Belfast and Heysham.

2.—EXPERIMENTS ON THE GROWTH OF *ULVA*.

The objects of these experiments were:—

(1) To compare the growth of *Ulva* (as measured by increase in area)* in various mixtures of polluting liquids, natural or artificial, with the growth of this seaweed in pure sea-water.

(2) To determine if possible which was the most stimulating constituent of those liquids found to promote growth.

(3) To observe the changes in composition of the seaweed, if any, after growth in these mixtures.

The methods by which these experiments were carried out were as follows:—

(1) *Glass Dish Experiments.*—Circular glass dishes holding each about four litres were used. Three litres of seawater† or of mixture were placed in each dish and a glass plate was laid on the top to exclude dust. The first series of experiments in June—July, 1909, was made with the dishes placed in a large box in the open with the lid at an angle of about 45°. All the subsequent experiments up to June, 1910, were made in a specially constructed house. This house was enclosed on three sides and roofed, the fourth side facing North was left quite open. The dishes were carried on three tiers of shelves running along the back wall. In order to be able to control the light falling on the dishes, adjustable blinds were fitted over the shelves.

(2) *Imitation Tidal Tank Experiments.*—These tanks were designed to imitate more closely the natural conditions of *Ulva* growing in tidal waters, the glass dish method being obviously unsatisfactory in this respect. Two stone-ware tanks were used for each experiment, one at a higher level and larger than the other. The upper one served as a feeder for the lower and was fitted with a glass stop cock so regulated as to fill the lower tank to a certain level in 6 hours. The lower tank (high water capacity 11 litres) was also fitted with a similar stop cock connected with a small glass floating arm and was regulated in such a way that in 6 hours 40 per cent. of the contents of the tank ran off.

This corresponds—according to the City Surveyor's calculations—with the amount of water entering Belfast Lough on the flood tide and passing out on the ebb.

A layer of sand, washed and sterilized by heating, to kill periwinkles, etc., was placed at the bottom of each tank. A shelf of brick was also arranged at such a level that *Ulva* placed on it was left uncovered for about an hour at artificial low water, while the sandy bottom was permanently submerged.

The tanks were worked as follows:—

Suppose the lower tank full to high water mark; the man in charge opens a pinch cock connected with the floating arm of this tank and allows the water to run off for 6 hours. Artificial low water is thus reached. He then closes this pinch cock and opens the one connected to the upper tank, until at the end of 6 hours as much water has run into the tank as had run off in the previous 6 hours. This cycle is repeated as long as the experiment lasts.

(3) *Timber Pond Bay Experiments.*—These experiments were designed to ascertain as far as possible the extent of growth of *Ulva* under natural conditions in the polluted water of Belfast Lough.

The water in the Timber pond channel* is polluted in varying degree according to the state of the tide and weather. At high water in ordinary weather the pollution is shown by analysis to be equivalent to about 1 per cent. of Belfast sewage as measured by the ammoniacal nitrogen. During the ebb tide in stormy weather, when the overflows on the main sewer are in operation the pollution may rise to 25 per cent. or higher. Owing to the constructional works going on at the Pumping Station in the summer of 1910, the overflow valves were in operaton whenever there was any increase on the dry weather flow of sewage. The average pollution during June and July, 1910, would probably be from 5 to 10 per cent. Belfast sewage.

In the earlier experiments made in 1909 the weeds under observation were placed on the floor of the bay, which was divided into compartments by bricks set two deep on the bottom. Very great difficulty was experienced in keeping the fronds in their proper compartments owing to the wash of the tide. Small crabs also interfered with the *Ulva* and identification of the individual fronds was not easy. Moreover the silt deposited in the bay was an objectionable feature and canvas screens were arranged so as to exclude this as much as possible.

Notwithstanding these difficulties many very striking observations were recorded on the rapid growth of *Ulva* under these conditions.

With the idea of avoiding some of the above difficulties the scheme was modified in 1910. Three boxes were made each divided into four equal compartments (12 × 12 × 12 inches) by perforated partitions. The boxes were weighted so that they floated with a free-board of about one-third their depth. They were tied together and to the shore in such a way that they floated as soon as the flood tide rose 6 inches on the floor of the bay. The fronds of *Ulva* were placed in the compartments and no difficulty was experienced in keeping them safely throughout the experiments.

The only trouble now arose from the storm overflows being so frequently in operation as mentioned above. This necessitated constant washing out of the bay to keep it clear of sewage solids.

METHOD OF MEASURING THE GROWTH OF ULVA FRONDS FROM INCREASE OF AREA.

The fronds used in these experiments were of two kinds, namely: (1) Squares cut from a large frond; and (2) whole fronds.

Regarding (1) a large healthy frond of *Ulva* was selected, and as many squares as possible 3 in. × 3 in. cut from it by means of a sharp knife. The unused portions of each of the large fronds were reserved for analysis. In one case as many as forty squares were cut from one large frond.

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* Later measured by a different method, based on increase of weight.

† Pure seawater from the Irish Channel (Series A.), *see* p. 105.

* This channel which skirts one end of the works at No. 2 Pumping Station is an artificial cut which has been constructed fairly recently.

In order to utilise it for experimental purposes, a branch was dug in its side which abuts on the Pumping Station, and at right angles to its course. This branch was about 19 feet in length and about 3 feet wide. The average rise of tide in it was 4 feet 6 inches, and it was flooded during each tide for an average period of 7 hours.

(2) Young fronds of a convenient size, namely 4 to 6 inches long, were chosen, usually from the pools on the Co. Down sloblands, and always such as were rooted to a stone or other support, and not such as were merely attached by the byssus threads of mussels. In the case of both cut squares and whole fronds (both before and after such growth) the area was measured by placing the leaf on a sheet of ground glass and tracing its outline with a pencil. The tracing was then transferred to paper and measured with a planimeter.

Composition of Sewage and Effluent used in the Experiments on the Growth of Ulva in Mixtures with Sea-Water.

(Results as parts per 100,000.)

Sewage.

Mean of daily analyses made during one year ending November, 1909 :—

Ammoniacal Nitrogen - - - - 2·001
Organic Nitrogen * - - - - 1·946

Sprinkler Effluent.

Mean of twenty analyses made between July 29th and October 14th, 1909 :—

Ammoniacal Nitrogen - - - - 0·31
Nitric and Nitrous Nitrogen - - - 1·74

Notes on the Experiments Generally.

In all these experiments on the growth of *Ulva* it is necessary to point out how carefully all the factors must be considered before any attempt is made to draw conclusions from the actual results obtained. In the first place, fronds of *Ulva* from the same locality and of the same size will often behave quite erratically when placed in the same mixture: one frond may show little or no growth and another grow rapidly under similar conditions. This is only what might be expected after all, judging from the analogous case of land plants. Only after many separate experiments in repetition have given similar results, can conclusions be thought about. In the limited time available for these experiments there are many questions which must remain open because of the small number of observations, but certain broad issues are well defined, and conclusions therefrom may legitimately be drawn.

Another difficulty arose from the rapid bleaching and decay of the *Ulva* in the experimental tanks. Perfectly healthy fronds would sometimes bleach to a mere transparent film in a day or two after they were transferred to the dishes ; in some cases nearly the whole of a batch of 100 fronds would be affected in this way, at other times no trouble would be experienced. The reproductive methods of *Ulva* are accompanied by a bleaching of the frond as the zoospores leave the cells, so that some of these fronds may have been fruiting.

Whatever the cause, the effect was to spoil completely a large number of the comparative experiments. The glass dishes suffered most, but both the Timber pond bay and the tidal tanks showed some cases.

It was soon noticed that *light* was a great stimulant to bleaching. If the dishes were well shaded it never occurred, but growth was also practically inhibited.

We also found that the pure sea-water brought from some miles outside Blackhead did not always remain free from ammonia when placed in the glass dishes for a few days. In some cases quite appreciable increase occurred. A sample which was free from ammonia when placed in the dishes contained as much as 0.004 per 100,000 after 4 days. As the experiments were being made on the sewage works where there is a possibility of pollution from external sources, it was thought well to arrange a control experiment in dishes protected by an acid seal, so that any ammonia would be trapped before reaching the pure sea water. Two experiments were thus made in Series 8 and 9, but the results were similar to those made in the unsealed dishes.

We have since found evidence that the decay of the natural plankton in pure seawater can produce ammonia in water originally free from this. (*See* p. 106 of this Report.)

In the following tables the results of the experiments on the growth of *Ulva* as measured by increase in area are arranged thus :—

Tables I.–XI.—Glass Dish Experiments.
Tables XII.–XIII.—Imitation Tidal Experiments.
Tables XIV.–XV.—Timber Pond Channel Bay Experiments.

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* Albuminoid nitrogen found in twelve series of analyses made some years ago was 0·88.

TABLE I.—GLASS DISH EXPERIMENTS.

(Older Series.)

SERIES 1 AND 2A.

Cut Squares.

Percentage Increase in Area in Various Mixtures of Screened and Settled Sewage (Paper Filtered) and Seawater (from Belfast Lough).

Month.	Number of Weeks' Growth.	Percentage Increase in Area.				
		1 Per Cent. Sewage.	5 Per Cent. Sewage.	10 Per Cent. Sewage.	20 Per Cent. Sewage.	30 Per Cent. Sewage.
June	1	—	21	36	47	—
,,	2	—	84	—	—	—
June—July	1	—	37	42	64	31
,, ,,	2	—	69	88	96	110
,, ,,	3	—	79	—	127	201
,, ,,	4	—	—	—	143	285
,, ,,	5	—	—	—	170	344
July—August	1	34 63	32	20	40	356
,, ,,	2	39 77	80	61	76	(6 weeks.)
,, ,,	3	—	110	97	106	—
,, ,,	4	—	130	112	116	—
,, ,,	5	—	144	123	—	—
,, ,,	6	—	—	128	—	—

TABLE II.—GLASS DISH EXPERIMENTS.

(Older Series.)

SERIES 1 AND 2B.

Cut Squares.

Percentage Increase in Area in Various Mixtures of Sprinkler Effluent (Paper Filtered) and Seawater (from Belfast Lough).

Month.	Number of Weeks' Growth.	Percentage Increase in Area.				
		1 Per Cent. Effluent.	5 Per Cent. Effluent.	10 Per Cent. Effluent.	20 Per Cent. Effluent.	30 Per Cent. Effluent.
June	1	—	—	28	39	31
,,	2	—	—	—	51	—
,,	3	—	—	—	61	—
June—July	1	—	17	52	46	33
,, ,,	2	—	44	152	63	106
,, ,,	3	—	72	220	74	163
,, ,,	4	—	130	256	—	184
,, ,,	5	—	177	290	—	206
July—August	1	14 2	15 46	39	31	34
,, ,,	2	22 5	24	61	56	100
,, ,,	3	—	43	66	74	144
,, ,,	4	—	—	—	89	180

TABLE III.—GLASS DISH EXPERIMENTS.

SERIES 3.

Cut Squares.

Period of Growth = 4 *Weeks, July* 29*th to August* 25*th,* 1909.

Mixture.	Per cent. Increase in Area.	Weight per Sq. In. (Dry Frond) (At start = 0·01000 Gramme) At finish.	Per cent. Nitrogen. (Dry Frond) (At start = 4·99.) At finish	Per cent. Ash. (Dry Frond) (At start = 16·06.) At finish.
		Grammes.		
1 per cent. sewage - - - -	136	0·01063	3·66	11·71
5 ,, ,, ,, - - - -	163	0·01467	4·87	13·46
10 ,, ,, ,, - - - -	161	0·01690	5·57	12·86
20 ,, ,, ,, - - - -	60	0·01763	6·54	12·28
30 ,, ,, ,, - - - -	69	0·01840	6·20	13·85
1 ,, ,, sprinkler effluent -	163	0·01152	3·86	15·28
5 ,, ,, ,, ,, -	172	0·01316	5·22	16·32
10 ,, ,, ,, ,, -	174	0·01252	5·13	13·29
20 ,, ,, ,, ,, -	78	0·01410	5·99	13·04
30 ,, ,, ,, ,, -	96	0·01541	5·59	14·49
Pure seawater (2 weeks) - -	46	0·00748	2·55	—

Remarks.

The Sewage Mixture.—With the exception of the 1 per cent. mixture, there is a gradual *increase* in weight per sq. in., and also a gradual *increase* in nitrogen content up to, and including the 20 per cent. mixture.

The Sprinkler Effluent Mixture.—To a certain extent the above remarks apply here also.

The Pure Seawater.—Both the weight per sq. in. and the nitrogen content, have *decreased* materially.

TABLE IV.—GLASS DISH EXPERIMENTS.

SERIES 4*.

Cut Squares.

Period of Growth = 3 *Weeks* (*August* 26*th to September* 16*th,* 1909) *in the Sewage and Sprinkler Effluent Mixtures and in the first Pure Seawater experiment. In all the others* = 4 *weeks* (*August* 19*th to September* 16*th,* 1909).

Mixture.	Per cent. Increase in Area.	Weight per Sq. In. (Dry Frond) (At start = 0·01000 Gramme) At finish.	Per cent. Nitrogen. (Dry Frond) (At start = 3·815.) At finish.	Per cent. Ash. (Dry Frond) (At start = 14·62.) At finish.
1 per cent. sewage - - -	2·1	—	5·75	9·33
5 ,, ,, ,, - - - -	0·0	—	—	—
10 ,, ,, ,, - - - -	0·0	—	5·13	9·97
20 ,, ,, ,, - - - -	0·0	—	5·13	10·30
30 ,, ,, ,, - - - -	0·0	—	4·30	8·84
1 ,, ,, sprinkler effluent -	5·2	—	4·59	5·51
5 ,, ,, ,, ,, -	7·4	—	4·89	8·91
10 ,, ,, ,, ,, -	15·2	—	4·86	4·33
20 ,, ,, ,, ,, -	14·3	—	5·35	10·53
30 ,, ,, ,, ,, -	11·6	—	5·74	7·25
Pure seawater - - - -	4·2 3·1	—	4·62	8·56
,, ,, - - - - -	11·8 11·8	—	4·03	8·44
Seawater over sludge - - -	0·0 5·4	—	3·81	20·91
1 per cent. pot ale - - -	4·5 0·0	—	4·48	8·65
Ammonium chloride :—				
(N = 2·5 per 100,000) -	0·0 3·2	—	4·77	8·87
(N = 0·025 per 100,000)] -	10·8 9·6	—	4·93	8·15
Potassium nitrate :				
(N = 2·5 per 100,000) -	10·0 5·1	—	5·17	8·04
(N = 0·025 per 100,000) -	10·0 4·2	—	4·77	8·13
Ammonium chloride + sodium phosphate				
(N = 2·5 per 100,000) -	8·6 0·0	—	5·11	8·63
(N = 0·025 per 100,000) -	21·8 8·4	—	5·51	7·63
Potassium nitrate + sodium phosphate :—				
(N = 0·025 per 100,000) -	6·3 19·6	—	4·93	7·79

* *Note.*—All the experiments of this series were conducted in very subdued light. Hence the small increase in area. *See* p. 75, "Notes on the Experiments Generally."

TABLE V.—GLASS DISH EXPERIMENTS.

SERIES 5.

Cut Squares, also whole Fronds attached to Stones or Shells.

Period of Growth = 4 weeks (September 16th to October 14th, 1909).

Mixture.	Cut Squares.			Percentage Increase in Area.	
	Weight per Sq. In. (Dry Frond). (At start = 0·01000 grammes).	Percentage of Nitrogen. (Dry Frond). (At start = 4·46).	Percentage of Ash. (Dry Frond). (At start = 17·99).	Cut Squares.	Whole Fronds.
	Grammes.				
1 per cent. sewage	0·01120	5·78	12·25	19	67
,, ,, ,,	0·01120			12	92
,, ,, ,, (in shade)	0·01132	5·17	—	18	33
5 ,, ,,	0·01150	4·69	11·65	28	75
,, ,, ,,	0·01219			10	96
,, ,, ,, (in shade)	0·01240	5·45	—	12	38
1 ,, sprinkler effluent	0·01313	4·68	11·13	26	96
,, ,, ,, ,,	0·00930			20	100
,, ,, ,, ,, (in shade)	0·01353	4·76	—	23	37
5 ,, ,, ,,	0·01003	5·04	13·43	29	113
,, ,, ,, ,,	0·01043			15	81
	New squares.	N at start = 3·96	Ash at start = 16·84		
,, ,, ,, ,, (in shade)	0·00850	5·51	—	13	53 (Cut sq. decaying).
Pure seawater	0·01360	3·18	10·61	31	95
,, ,,	0·01104			36	72
,, ,, (in shade)	0·01302	3·64	9·61	22	52
,, ,, (in shade)	0·01234			23	100
75 per cent. pure seawater + 25 per cent. tap water	0·00985	3·43	8·35	55	126
,, ,, ,, ,, + 25 ,, ,, (in shade)	0·00975	5·53	—	10	27
50 ,, ,, ,, + 50 ,, ,,	0·00912	3·70	9·24	59	67
,, ,, ,, ,, + 50 ,, ,,	0·01108			59	65
,, ,, ,, ,, + 50 ,, ,, (in shade)	0·00805	3·71	9·46	44	53
,, ,, ,, ,, + 50 ,, ,, (in shade)	0·00963			51	70
Ammonium chloride (N = 0·025 per 100,000)	0·01312	4·02	9·48	52	109
,, ,, (N = 0·025 ,, 100,000)	—	—	—	—	129 (Cut sq. decayed).
,, ,, (N = 0·025 ,, 100,000) (in shade)	0·01012	5·49	10·43	5	51
,, ,, (N = 0·025 ,, 100,000) (in shade)	0·01168			6	24
Potassium nitrate (N = 0·025 per 100,000)	0·01213	Lost	8·89	4	26 3 weeks.
,, ,, (N = 0·025 ,, 100,000)	0·01164			35	40 Fronds decayed.
,, ,, (N = 0·025 ,, 100,000) (in shade)	—	5·08	15·56	3	61
,, ,, (N = 0·025 ,, 100,000) (in shade)	0·01164	4·95	13·98	3	34
Ammonium chloride + sodium phosphate + ferrous sulphate (N = 0·025 per 100,000. P = 0·0025. Fe = 0·025)	0·00980	5·08	8·99	24	109
Ditto. Ditto. Ditto.	0·00930			12	62
	New squares.	N at start = 4·59	Ash at start = 17·67		
Ditto. Ditto. Ditto.	—	4·96	10·56	17	50
Ditto. Ditto. Ditto.	—			8	16 Frond decayed.

TABLE VI.—GLASS DISH EXPERIMENTS.

SERIES 5 A.

CUT SQUARES. (NEW SQUARES AT START OF EXPERIMENTS.)

Period of Growth = *5 Months.* (*October 29th*, 1909, *to March 16th*, 1910.

The Figures in the Columns Refer to the Percentage Increase in Area only, during each of the Periods Named.

Mixture.	October 29th to November 12th. (2 Weeks.)	November 12th to December 14th. (4 Weeks.)	December 14th to January 14th. (1 Month.)	January 14th to February 16th. (1 Month.)	February 16th to March 16th. (1 Month.)	Total.	Average.
1 per cent sewage	1	2	0	1	2	6	4
„ „	0	1	1	1	1	4	
„ „	3	0	0	0	0	3	
5 „ „	1	2	0	−1	2	4	8
„ „	4	15	4	3	3	29	
„ „	0	1	1	0	0	2	
1 per cent. Sprinkler effluent	0	3	−1	1	−1	2	5
„ „ „	2	5	0	2	2	11	
„ „ „	0	2	1	1	0	4	
5 „ „ „	0	0	—	—	—	0	5
„ „ „	0	9	1	—	—	10	
„ „ „	2	2	0	0	1	5	
Pure seawater	0	1	10	−10	1	2	10
„ „	0	0	—	—	—	0	
„ „	1	9	7	2	1	20	
„ „	1	10	4	2	1	18	
75 per cent. pure seawater + 25 per cent. tap water	0	—	—	—	—	0	2
„ „ „ + 25 „ „	3	3	3	−4	—	5	
50 „ „ „ + 50 „ „	7	6	5	4	—	22	12
„ „ „ + 50 „ „	4	2	0	—	—	6	
„ „ „ + 50 „ „	4	6	3	1	0	14	
„ „ „ + 50 „ „	3	3	3	0	−1	8	
Ammonium chloride (N = 0·025 per 100,000)	3	10	0	0	—	13	7
„ „ „ „	0	—	—	—	1	0	
„ „ „ „	0	0	0	0	1	1	
„ „ „ „	0	1	2	−2	5	6	
Potassium nitrate (N = 0.025 per 100,000)	0	1	1	−2	3	3	6
„ „ „ „	5	2	—	—	—	7	
„ „ „ „	4	7	—	—	—	11	
„ „ „ „	0	3	1	−1	0	3	
Ammonium chloride + sodium phosphate + ferrous sulphate (N = 0·025 per 100,000. P = 0.0025. Fe = 0.025)	0	0	0	0	—	0	2
	0	2	0	0	—	2	
	0	0	0	—	—	0	
	1	1	0	1	2	5	

Remarks.—(1) It is probable that the error in measuring the area of the cut squares used in these experiments amounted to at least 5 per cent. and possibly to more, so that very little, if any, growth occurred in any of the above experiments from November to March. "—" (Blank) denotes that the square had decayed. (2) In calculating the averages all *minus* quantities have been reckoned as 0.

TABLE VII.—GLASS DISH EXPERIMENTS.

SERIES 5 A.

WHOLE FRONDS ATTACHED TO SHELLS OR STONES. (THE SAME FRONDS AS WERE PLACED IN THE DISHES ON *September 16th*, SERIES 5.)

Period of Growth = 5 *Months.* (*October 15th*, 1909, *to March 16th*, 1910.)

The Figures in the Columns refer to the Percentage Increase in Area during each of the Periods Named.

Mixture.	October 15th to October 29th. (2 Weeks.)	October 29th to November 12th. (2 Weeks.)	November 12th to December 14th. (4 Weeks.)	December 14th to January 14th. (4 Weeks.)	January 14th to February 16th. (4 Weeks.)	February 16th to March 16th. (4 Weeks.)	Total.	Average.
1 per cent. sewage	6	34	—	—	—	—	40	18
,, ,, ,,	−7	—	—	—	—	—	−7	
,, ,, ,,	0	7	0	0	0	7	4	
5 ,, ,,	7	7	3	—	—	—	11	9
,, ,, ,,	8	3	—	—	—	—	11	
,, ,, ,,	0	−5	−3	0	0	5	5	
1 per cent. sprinkler effluent	−7	—	—	—	—	—	7	4
,, ,, ,, ,,	−2	−53	—	—	—	—	−55	
,, ,, ,, ,,	6	7	−7	—	—	—	6	
5 ,, ,, ,,	—	—	—	—	—	—	0	20
,, ,, ,, ,,	19	19	20	9	−20	—	47	
,, ,, ,, ,,	7	13	−6	0	—	—	14	
Pure seawater	10	−4	—	—	—	—	6	20
,, ,,	7	0	4	—	—	—	11	
,, ,,	19	6	—	—	—	—	25	
,, ,,	29	9	—	—	—	—	38	
75 per cent. pure seawater + 25 per cent. tap water	33	7	—	—	—	—	40	28
,, ,, ,, ,, + 25 ,, ,,	11	5	0	0	—	—	16	
50 ,, ,, ,, + 50 ,, ,,	19	12	—	—	—	—	31	33
,, ,, ,, ,, + 50 ,, ,,	−4	—	—	—	—	—	0	
,, ,, ,, ,, + 50 ,, ,,	4	20	14	8	5	2	53	
,, ,, ,, ,, + 50 ,, ,,	14	11	24	—	—	—	49	
Ammonium chloride (N = 0·025 per 100,000)	−32	—	—	—	—	—	−32	2
,, ,, ,, ,,	−8	10	—	—	—	—	2	
,, ,, ,, ,,	0	6	0	—	—	—	6	
,, ,, ,, ,,	−7	—	—	—	—	—	−7	
Potassium nitrate (N = 0·025 per 100,000)	—	—	—	—	—	—	0	2
,, ,, ,, ,,	—	—	—	—	—	—	0	
,, ,, ,, ,,	—	—	—	—	—	—	0	
,, ,, ,, ,,	8	—	—	—	—	—	8	
Ammonium chloride + sodium phosphate + ferrous sulphate (N = 0·025 per 100,000. P = 0·0025. Fe = 0·025)	0	5	2	—	—	—	7	22
	8	1	−43	—	—	—	−34	
	28	24	21	6	3	—	80	
	—	—	—	—	—	—	0	

Remarks.—(1) It is probable that the error in measuring the area of the attached fronds used in these experiments amounted to at least 5 per cent., and possibly to more.

(2) In calculating the averages all *minus* quantities have been reckoned as 0.

TABLE VIII.—GLASS DISH EXPERIMENTS.

SERIES 6.

Cut Squares and Whole Fronds.

Period of Growth = 4 *weeks* (*April* 21*st to May* 19*th*, 1910).

Mixture.	Per cent. Increase in Area.	
	Cut Squares.	Whole Fronds.
1 per cent. sewage	5	0
5 ,, ,,	15	21
10 ,, ,,	15	47
20 ,, ,,	20	25
30 ,, ,,	20	57
1 ,, sprinkler effluent	16	19
5 ,, ,, ,,	27	71
10 ,, ,, ,,	17	86
20 ,, ,, ,,	9	26
30 ,, ,, ,,	56	40
Pure seawater	3	0
,, ,,	2	8

TABLE IX.—GLASS DISH EXPERIMENTS.

SERIES 7.

Cut Squares, also Whole Fronds attached to Stones or Shells.

Period of Growth = 4 *weeks* (*June* 2*nd to June* 30*th*, 1910).

Mixture.	Cut Squares.	Percentage Increase in Area.	
	Weight per Sq. In. (Dry Frond). (At start = 0·00989 grammes).	Cut Squares.	Whole Fronds.
	Grammes.		
1 per cent. sewage	0·01234	44	43
5 ,, ,,	0·01353	97	5
10 ,, ,,	0·01357	105	20
20 ,, ,,	0·01265	82	41
30 ,, ,,	0·01405	55	153
1 ,, sprinkler effluent	0·01324	70	63
5 ,, ,, ,,	0·01633	44	48
10 ,, ,, ,,	0·01149	48	84
20 ,, ,, ,,	0·01384	125	62
30 ,, ,, ,,	0·01325	106	173
Pure seawater	0·01306	32	16
,, ,,	0·01294	20	18
90 per cent. seawater + 10 per cent. tap water	—	31	42
,, ,, ,, ,, ,, ,, ,,	—	44	100
,, ,, ,, ,, ,, ,, ,,	—	26	43
,, ,, ,, ,, ,, ,, ,,	—	9	28
75 ,, ,, + 25 ,, ,,	—	30	46
,, ,, ,, ,, ,, ,, ,,	—	25	40
,, ,, ,, ,, ,, ,, ,,	—	37	100
,, ,, ,, ,, ,, ,, ,,	—	6	26
80 per cent. seawater + 19 per cent. tap water + 1 per cent. sewage	0·01439	50	30
Ditto	0·01285	69	82
Ammonium chloride (N = 0·025 per 100,000)	—	62	6
Ditto	—	11	14
Potassium nitrate (N = 0·025 per 100,000)	—	23	0
Ditto	—	5	24

TABLE X.—GLASS DISH EXPERIMENTS.
SERIES 8.

CUT SQUARES AND WHOLE FRONDS.

Period of Growth = 4 *weeks* (*July* 1*st to July* 28*th*).

Mixture.	Per cent. Increase in Area.			
	Cut Squares.		Whole Fronds.	
1 per cent. sewage	0	21	81	—
5 ,, ,,	13	26	91	134
10 ,, ,,	43	32	149	428
20 ,, ,,	43	88	137	402
30 ,, ,,	13	86	284	336
1 ,, sprinkler effluent	13	23	52	—
5 ,, ,, ,,	33	31	—	187
10 ,, ,, ,,	59	60	197	—
20 ,, ,, ,,	59	110	—	—
30 ,, ,, ,,	46	151	—	160
Pure seawater	25	17	91	—
,, ,,	10	23	—	—
90 per cent. seawater + 10 per cent. tap water	14	7	78	—
Ditto	11	29	—	—
75 per cent. seawater + 25 per cent. tap water	20	20	141	—
80 per cent. seawater + 19 per cent. tap water + 1 per cent. sewage	11	12	34	91
Acid sealed dishes. 5 per cent. sewage	22	—	114	—
Acid sealed dishes. Pure seawater	38	21	59	102

TABLE XI.—GLASS DISH EXPERIMENTS.
SERIES 9.

Period of Growth = 4 *weeks* (*July* 28*th to August* 26*th*, 1910).

Mixture.	Per cent. Increase in Area.			
	Cut Squares.		Whole Fronds.	
1 per cent. sewage	14	25	45	63
5 ,, ,,	32	49	48	89
10 ,, ,,	85	72	82	111
20 ,, ,,	105	28	113	114
30 ,, ,,	20	96	87	340
1 ,, sprinkler effluent	37	39	75	55
5 ,, ,, ,,	—	12	68	84
10 ,, ,, ,,	79	62	200	116
20 ,, ,, ,,	—	29	78	83
30 ,, ,, ,,	81	100	160	94
Pure sea water	21	14	79	24
,, ,,	13	18	80	43
90 per cent. seawater + 10 per cent. tap water	16	9	40	51
Ditto	9	—	26	—
80 per cent. seawater + 19 per cent. tap water + 1 per cent. sewage	17	10	63	70
Acid sealed dishes. 5 per cent. sewage	4	—	31	—
Acid sealed dishes. Pure seawater	7	9	39	2

TABLE XII.—IMITATION TIDAL EXPERIMENTS. SERIES 10.

CUT SQUARES ALSO WHOLE FRONDS ATTACHED TO STONES OR SHELLS.

Period of Growth = 4 *weeks* (*July* 29*th to August* 26*th*, 1909).

Tank.	Mixture.	Per cent. Increase in Area.	Weight per Sq. In. (Dry Frond.) (At start = 0·01000 Gramme	Per cent. Nitrogen. Dry Frond.) (At start = 3·72.	Per cent. Ash. (Dry Frond.) (At start = 32·92.
	Cut Squares.				
			Grammes.		
No. 1	Slob.* Pure seawater	10	0·01252	4·07	19·28
	Deep. ,, ,,	5	0·01290	3·95	22·03
No. 2	Slob. 1 per cent. sewage	11	0·01176	4·96	15·51
	Deep. ,, ,,	10	0·01314	6·68	22·72
No. 3	Slob. 1 per cent. sprinkler effluent	7	0·01223	3·36	14·22
	Deep. ,, ,, ,,	6	0·01321	3·02	22·43
	Whole Fronds.				
No. 1	Slob. Pure seawater	37	—	4·90*	16·66†
	Deep. ,, ,,	68	—	4·03	18·25
No. 2	Slob. 1 per cent. sewage	40‡	—	4·51	17·84
	Deep. ,, ,,	57‡	—	4·01	18·45
No. 3	Slob. 1 per cent. sprinkler effluent	27	—	4·69	18·71
	Deep. ,, ,, ,,	—‡	—	4·13	19·08

* Per cent. nitrogen at start, not ascertainable. † Per cent. ash at start, not ascertainable.

‡ Eaten by periwinkles.

TABLE XIII.—IMITATION TIDAL EXPERIMENTS. SERIES 11.

CUT SQUARES AND WHOLE FRONDS ATTACHED TO STONES OR SHELLS.

Period of Growth = 8 *weeks* (*September* 16*th to November* 11*th*, 1909).

Tank.	Mixture.	Per cent. Increase in Area.	
		Cut Squares.	Whole Fronds.
No. 1	Slob. Pure seawater	10	44
	Deep. ,, ,,	12	25
No. 2	Slob. 5 per cent. sewage	9	25
	Deep. ,, ,,	11	18
No. 3	Slob. 5 per cent. sprinkler effluent	13	40
	Deep. ,, ,, ,,	13	29
No. 4	Slob. Ammonium chloride (N = 0·025 per 100,000)	13	18
	Deep. ,, ,, ,, ,,	8	15
No. 5	Slob. Potassium nitrate (N = 0·025 per 100,000)	15	23
	Deep. ,, ,, ,, ,, ,,	13	2

* The "slob" here signifies the artificial conditions described on p. 74, under "Imitation Tidal Tank Experiments."

TABLE XIV.—TIMBER POND CHANNEL BAY EXPERIMENTS.
SERIES 14, 15 AND 16.

CUT SQUARES AND WHOLE FRONDS ATTACHED TO SHELLS OR STONES.
Period of Growth as Stated.
Cut Squares and Whole Fronds.

Date. 1909.	Number of weeks growth.	Percentage increase in Area.								
		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.
June - - - - - - - - -	1	24 146	23 18	49 —	52 —	339*134*	55*—	267 —	30†—	67†—
,, - - - - - - - - -	2	— —	— —	114 —	197 —	— —	104 —	353 —	296 —	113 —
,, - - - - - - - - -	3	— —	— —	294 —	503 —	— —	173 —	— —	— —	367 —
June to July - - - - - - -	1	101 31	— —	45 23	33 —	— —	96 36	137 —	— —	— —
,, ,, ,, - - - - - - -	2	— 41	— —	— —	— —	— —	— —	163 —	— —	— —
July to August - - - - - - -	1	33 12	61 —	106 —	47 70	112 —	67 —	— —	78 —	— —
,, ,, ,, - - - - - - -	2	— —	57 —	— —	— —	240 —	— —	— —	— —	— —

* *Ulva Linza* (but it may be a broad form of *Enteromorpha intestinalis*).
† Cut squares.

TABLE XV.—TIMBER POND CHANNEL BAY EXPERIMENTS.
SERIES 17 AND 18.

CUT SQUARES AND WHOLE FRONDS ATTACHED TO SHELLS AND STONES.
Period of Growth as Stated.
Cut Squares.

Date. 1910.	Number of weeks growth.	Percentage increase in Area.											
		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
June 17th to July 1st - - -	2	60	75	81	74	116	52	68	72	—	—	—	—
,, 17th ,, ,, 15th - - -	4	124	245	237	197	380	191	205	174	—	—	—	—
,, 17th ,, ,, 29th - - -	6	424	561	463	460	—	447	684	455	—	—	—	—
July 29th to August 12th - -	2	98	100	65	136	47	58	72	43	124	66	14	81
.. 29th .. ,, 26th - -	4	156	180	—	—	145	—	—	150	—	—	—	—
Whole Fronds.													
June 17th to July 1st - - -	2	—	—	—	—	144	70	86	60	50	84	60	60
,, 17th ,, ,, 15th - - -	4	—	—	—	—	—	—	—	336	145	183	126	127
,, 17th ,, ,, 29th - - -	6	—	—	—	—	—	—	—	—	372	368	325	249
July 29th to August 12th - -	2	117	164	147	154	180	121	63	134	130	92	180	88
.. 29th ,, August 26th - -	4	221	318	240	—	307	182	214	203	310	—	—	117

RESULTS OF THE EXPERIMENTS ON THE GROWTH OF ULVA IN GLASS DISHES AS MEASURED BY INCREASE IN AREA.

It is by no means an easy or simple matter to combine the results of the numerous experiments made, so as to obtain a clear idea of the relative rates of growth of *Ulva* in pure seawater and in some of the chief polluting mixtures.

One way, which has certain advantages, is to take the results in one growing season, *i.e.*, from April to October, and to calculate the average increase in area per month, giving separate tables for the cut squares and for the whole fronds. This has been done in the two following tables, but for the reasons mentioned on p. 75 the number of experiments is too small to warrant more than the most general conclusions. The results for pure seawater plus 1 per cent. sewage, and 1 per cent. effluent mixtures are the most reliable as experiments made with them were more numerous.

TABLE XVII. GROWTH OF *ULVA* AS MEASURED BY INCREASE IN AREA.

Glass Dish Experiments.

(CUT SQUARES.)

July to October, 1909. *April to June*, 1910.

SERIES 2 to 7.

Increase in Area of Fronds grown in seawater polluted with sedimented sewage. Results expressed as percentage increase in four weeks.

Mixture with seawater.		Number of Experiments.	Percentage Increase in Area.
Sedimented Sewage	1 per cent. -	5	50
	5 ,, -	6	69
	10 ,, -	4	85
	20 ,, -	4	63
	30 ,, -	3	48
Seawater Polluted with Percolating Filter Effluent.			
Percolating Filter Effluent	1 per cent. -	5	68
	5 ,, -	5	66
	10 ,, -	3	80
	20 ,, -	4	73
	30 ,, -	4	100
Unpolluted Seawater.			
Pure seawater - -		6	39
Seawater + 25 per cent. tap water - - -		4	43

(Whole Fronds.)

September to October, 1909. *April to August*, 1910.

SERIES 5 TO 9.

Mixture with seawater.		Number of Experiments.	Percentage Increase in Area.
Sedimented Sewage	1 per cent.	7	52
	5 ,, -	8	59
	10 ,, -	6	113
	20 ,, -	6	112
	30 ,, -	6	183
Seawater Polluted with Percolating Filter Effluent.			
Percolating Filter Effluent	1 per cent. -	7	59
	5 ,, -	7	96
	10 ,, -	5	131
	20 ,, -	4	56
	30 ,, -	5	125
Unpolluted Seawater.			
Pure seawater - - -		10	50
Sea water + 25 per cent. tap water - - -		6	107

We think that the conclusions to be drawn from these results are that under the conditions of experiment:

(1) *Ulva* can grow in pure sea water.

(2) The dilution of pure sea water with tap water, *i.e.*, a certain degree of brackishness, is not inimical to the growth of *Ulva* but rather promotes it.

(3) Pollution of pure seawater either by sedimented sewage or by percolating filter effluent causes a very marked increase in growth compared with fronds grown in pure sea water. The rate of increase appears to be proportional to the concentration of pollution up to the 10 per cent. mixtures, but above this the results are irregular. (In July at the period of most vigorous growth, the greatest increase occurs in the most polluted mixtures—no doubt because the *Ulva* can then cope with more extensive pollution than at other times.)

It should, however, be noted that in *certain* of the experiments, the growth of *Ulva* in pure seawater was actually greater, or not very much less, than that in the mixtures containing 1 per cent. sewage or sprinkler effluent, and as we shall show later on in this report a pollution corresponding with the former is actually found in the waters flowing over the sloblands in Belfast Lough, in those parts where the most extensive beds of *Ulva* are situated.

On referring to the Tables, it will be found that the above statement is true as regards 1 per cent. sewage in the cases of Series 5, 6 and 9 (both cut squares and whole fronds) and also in 7 and 8 (cut squares only). In Series 3, however, the growth in the polluted mixture, is *three* times as great as in the pure seawater and at a time of the year when experience has shown that under natural conditions, the growth of the seaweed is particularly rapid—and as a consequence, the nuisance often at its worst.

The growth of *Ulva* in the 1 per cent. sprinkler effluent mixture was distinctly greater than that in pure seawater in Series 3, 6, 7 and 9 (cut squares), also in 6 and 7 (whole fronds), and slightly greater (average) in Series 9 (whole fronds).

Another way is to consider *all* the results (relating to pure sea water and mixtures of the same with sewage and sprinkler effluent), and for this purpose the following table has been constructed :—

TABLE XVIII.—GROWTH OF *ULVA* AS MEASURED BY INCREASE IN AREA.

GLASS DISH EXPERIMENTS.

SUMMARY AND AVERAGES.

(Cut Squares.)

	1909 to 1910.						1910.			
	June. (2 Weeks.) Series 1 and 2.	June to July. (4 Weeks.) Series 1 and 2.	July to August. (4 Weeks.) Series 1, 2 and 3	August to September. (4 Weeks.) Series 4	September to October. (4 Weeks.) Series. 5	October to March. (20 Weeks.) Series 5 (A)	April to May. (4 Weeks.) Series 6	June. (4 Weeks.) Series 7	July. (4 Weeks.) Series 8	August. (4 Weeks.) Series 9
Sewage* 1 per cent.	—	—	— 136	2	19 12 18	6 4 3	5	44	0 21	14 25
5 ,,	—	—	130 163	0	28 10 12	4 29 2	15	97	13 26	32 49
10 ,,	—	—	112 161	0	— — —	— — —	15	195	43 32	85 72
20 ,,	84	143	116 60	0	— — —	— — —	20	82	43 88	105 28
30 ,,	—	285	— 69	0	— — —	— — —	20	55	13 86	20 96
Sprinkler Effluent † 1 ,,	—	—	— 163	5	26 20 23	2 11 4	16	70	13 23	37 39
5 ,,	—	130	— 172	7	29 15 13	0 10 5	27	44	33 31	— 12
10 ,,	—	256	— 174	15	— — —	— — —	17	48	59 60	79 62
20 ,,	51	—	59 78	14	— — —	— — —	9	125	59 110	— 29
30 ,,	—	184	180 96	11	— — —	— — —	56	106	46 151	81 100
Pure seawater‡	—	—	46	4 3	31 36 22 23	2 0 20 18	3	32 20	25 17 10 23	21 14 13 18
*Average	84	214	118	0	16	8	15	94	36	52
† ,,	51	190	131	10	21	5	25	78	58	55
‡ ,,	—	—	46	3	28	10	3	26	19	16

(Whole Fronds.)

	1909 to 1910.						1910.			
	June. (2 Weeks.) Series 1 and 2.	June to July. (4 Weeks.) Series 1 and 2.	July to August. (2 Weeks.) Series 1, 2 and 3.	August to September. (4 Weeks.) Series 4	September to October. (4 Weeks.) Series 5	October to March. (20 Weeks.) Series 5 (A)	April to May. (4 Weeks.) Series 6	June. (4 Weeks.) Series 7	July. (4 Weeks.) Series 8	August. (4 Weeks.) Series 9
Sewage* 1 per cent.	— — —	— — —	— — —	—	67 92 33	40 −7** 14	0	43	81	45 63
5 ,,	— — —	— — —	— — —	—	75 96 38	11 11 5	21	5	91 134	48 89
10 ,,	— — —	— — —	— — —	—	— — —	— — —	47	20	149 428	82 111
20 ,,	— — —	— — —	— — —	—	— — —	— — —	25	41	137 402	113 114
30 ,,	— — —	— — —	— — —	—	— — —	— — —	57	153	284 336	87 340
Sprinkler Effluent† 1 ,,	— — —	— — —	— — —	—	96 100 37	7 −55** 6	19	63	52 –	75 55
5 ,,	— — —	— — —	— — —	—	113 81 53	0 47 14	71	48	— 187	68 84
10 ,,	— — —	— — —	— — —	—	— — —	— — —	86	84	197 —	200 116
20 ,,	— — —	— — —	— — —	—	— — —	— — —	26	62	— —	78 83
30 ,,	— — —	— — —	— — —	—	— — —	— — —	40	173	— 160	160 90
Pure seawater‡	— — —	— — —	— — —	—	95 72 52	6 11 25	0	16	91 —	79 24
,, ,,	— — —	— — —	— — —	—	100	38	8	18	— —	80 43
* Average	— — —	— — —	— — —	—	67	13	30	52	227	109
† ,,	— — —	— — —	— — —	—	80	12	48	86	149	101
‡ ,,	— — —	— — —	— — —	—	79	20	4	17	91	56

** All *minus* quantities reckoned as 0.

Averages.—In order to contrast the results recorded in Table XVIII. as a whole, in the cases of sewage and sprinkler effluent, a series of averages has been worked out which was arrived at as follows :—

The sums of all the experiments with the mixtures of different strengths of sewage or effluent have been added together, and the resulting figure divided by the total number of experiments made.

Thus, in the case of sewage and sea water, the mixtures experimented with, were—1 per cent., 5 per cent., 10 per cent., 20 per cent. and 30 per cent., or some of these. Ten series of experiments were made with cut squares and six with whole fronds in these mixtures, and for purposes of comparison it seemed desirable to draw up three sets of averages, calculated in the way described, namely, one for the cut squares, one for the whole fronds, and one for the two combined. The data were in this case :—

	No. of Experiments.	Sums of Per cent. Increase in Area of all Experiments.	Averages
Cut squares - - - - - -	53	3045	$\frac{3045}{53} = 57{\cdot}4$
Whole fronds - - - - - -	41	4028	$\frac{4028}{41} = 98{\cdot}5$
Total - - - - - - -	94	7073	$\frac{7073}{94} = 75{\cdot}2$

For contrasting the effects of pure sea water with those produced by sewage or the sprinkler effluent, a similar method was adopted, but the figures for the two first series were omitted as no experiments with pure sea water were made in them. Also, in the third series, the growth of *Ulva* in pure sea water was only observed for a fortnight (one experiment), while that in the mixtures of sewage and sprinkler effluent respectively (many experiments) was observed during twenty-eight days. For purposes therefore of calculation, the figure for the growth in pure sea water (in that particular series) has been doubled.

The averages (calculated as described above), are as follows :—

TABLE XIX.

	Cut Squares.		Whole Fronds.		Increase of Area.
	No. of Experiments.	Increase of Area. Averages.	No. of Experiments.	Increase of Area. Averages.	Total Averages.
Sewage - - - - - - -	53	57·4	41	98·5	75·2
Sprinkler effluent - - - -	56	58·8	36	78·6	66·6
Sewage - - - - - - -	50	50·7	41	98·5	72·1
Sprinkler effluent - - - -	52	50·1	36	78·6	62·5
Pure seawater - - - -	22	20·3	17	44·6	30·9

Growth in Polluted Mixtures (*Sewage and Sprinkler Effluent*).—It would not be safe, we think, to draw any but the broadest inferences from the series of averages thus calculated in conjunction with the details given in Table XVIII., but we are of the opinion that the following are warranted :—

(1) In the polluted mixtures (as defined above), a decided growth of *Ulva* began from April to May, reached a maximum rate of increase from June to August, and thereafter rapidly declined; being practically *nil* from October to March.

(2) On the whole, the attached fronds grew more rapidly than the cut squares.

(The above conclusions, drawn from the experiments in question as regards the period when active growth of *Ulva* commences, and also as to the time or season when the maximum of such growth is reached, correspond in general with what occurs (as a matter of observation) on the foreshores of Belfast Lough. But regarding the period after August, the sea-weed continues to be washed up and collected in quantity on these foreshores much later, and as a rule, until December—at least such was the case in recent years—and it is only in January, February and March, that the banks are sufficiently clear of *Ulva* to appear brown from their seaward margins, instead of green).

Growth in Pure Seawater.—As to the exact time when *Ulva* commenced active growth in these experiments in pure seawater, it will be seen from Table XVIII. that during the period April to May, growth was remarkably tardy compared with that in the polluted mixtures.

As to other seasonal relationships, in the following table we give the results of such of the series as admit of direct comparison in chronological order, giving the general averages for cut squares and whole fronds combined :—

TABLE XX.—GLASS DISH EXPERIMENTS.

Average Per Cent. Increases in Area.

	1909–1910.			1910.			
	August.	September to October.	October to March.	April to May.	June.	July.	August.
Sewage	117·8 (5)	41·7 (12)	10·7 (12)	22·5 (10)	64·5 (10)	126·7 (19)	80·9 (20)
Sprinkler effluent	136·6 (5)	50·5 (11)	8·8 (12)	36·7 (10)	82·5 (10)	84·3 (12)	80·7 (18)
Pure seawater	46·0 (1)	53·9 (8)	15·0 (8)	3·2 (3)	21·5 (4)	33·2 (5)	36·5 (8)

Note.—The figures in brackets show the total number of experiments in each case.

The results as thus compared bring out some very interesting features. Thus: (1) The period of maximum growth in pure seawater, was from September to October, when the stimulating effects of the sewage and sprinkler effluent were rapidly decreasing.

(2) The extent of growth of *Ulva* in pure sea water steadily increased from April to August.

(3) During the late autumn and winter months, the stimulating effects of the pure seawater were much greater than those of the sewage or the sprinkler effluent.*

Brackishness and Chemical Stimulants.—A comparison of the results on these points, both among themselves and also in relation to the effects of sewage, sprinkler effluent and pure seawater on the growth of the sea-weed is not exactly a simple matter, as the time at our disposal was not sufficient to make concurrent experiments with all the different mixtures.

As a consequence of this, we are unable to make as complete a series of comparisons as is desirable, and we must content ourselves with such as the available material permits of.

The matter may, we think, be treated in two different ways, of which the second is probably the fairest.

(1) A comparison of the averages of all the experiments in the different series. Treated in this way, the comparison is as follows:—

TABLE XXI.

Mixture.	No. of Series of Experiments made.	Total Number of Experiments.	Average Per cent. Increase in Area.
Sewage	16	94	75·2
Sprinkler effluent	16	92	66·6
Pure seawater alone	14	39	30·9
,, ,, + 10 per cent. tap water	6	19	32·2
,, ,, + 25 ,, ,,	8	19	40·5
,, ,, + 50 ,, ,,	4	8	40·7
Ammonium chloride (N = 0·025 per 100,000)	9	19	27·1
Potassium nitrate (N = 0·025 per 100,000)	9	22	13·8
Ammonium chloride + sodium phosphate + Ferrous sulphate (N and Fe = 0·025 per 100,000. P = 0·0025 ,,)	4	15	26·1

This method has the advantage of comparing a larger number of results, but on the other hand has the disadvantage of comparing them (in certain cases at all events) at entirely different seasons, and thus neglects a very important feature.

(2) A comparison of the results obtained in corresponding series only. This is done in the following table:—

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* Possibly because the fronds in the polluted mixtures having become "fat" during the warm months and being continuously supplied with nutriment, have no incentive to further growth; while the fronds in pure seawater are stimulated to extend their area in order that the meagre diet available may be more readily absorbed.

Another explanation might be, that under natural conditions, *i.e.* in seawater, the seasonal development of *Ulva* always proceeds by slower degrees.

TABLE XXII.—GLASS DISH EXPERIMENTS.

EFFECTS OF SEWAGE, SPRINKLER EFFLUENT, TAP WATER AND OF CERTAIN CHEMICAL SUBSTANCES ADDED TO PURE SEA WATER, ON THE GROWTH OF *ULVA*.

(Corresponding Series of Experiments only Contrasted.)

(*Average Per Cent. Increase in Area.*)

Mixture.		Cut Squares.		Whole Fronds.		
		Number of Experiments.	Average.	Number of Experiments.	Average.	Total Average.
Series 7, 8, 9.	Sewage - - - - - - - - - -	25	54·6	25	135·8	95·2
	Sprinkler effluent - - - - - - - -	23	75·1	19	107·3	82·5
	Pure sea water - - - - - - - -	10	19·3	7	50·1	32·0
	10 per cent. tap water - - - - - - -	11	18·6	8	51·0	32·2
Series 5, 5A, 7, 8.	Sewage - - - - - - - - - -	27	36·5	27	103·2	69·8
	Sprinkler effluent - - - - - - - -	26	40·2	21	75·2	55·8
	Pure sea water - - - - - - - -	14	19·9	11	47·6	32·1
	25 per cent. tap water - - - - - - -	10	20·8	9	62·4	40.5
Series 5, 5A	Sewage - - - - - - - - - -	12	12·2	12	40·2	26·2
	Sprinkler effluent - - - - - - - -	11	14·4	12	46·5	30·9
	Pure sea water - - - - - - - -	8	19·7	8	49·9	34·4
	25 per cent. tap water - - - - - - -	4	17·5	4	52·2	37·1
	50 per cent. tap water - - - - - - -	8	35·4	8	48·5	40·7
	Ammonium chloride (N = 0·025 per 100,000) -	7	11·8	6	53·3	31·1
	Potassium nitrate (N = 0·025 per 100,000) - -	8	8·6	8	21·1	14·9
	Ammonium chloride, etc. (N = 0·025 per 100,000) -	8	8·5	9	46·3	26·1
Series 4, 5, 5A, 7.	Sewage - - - - - - - - - -	17	36·5	17	32·0	34·3
	Sprinkler effluent - - - - - - - -	21	28·3	17	57·9	44·9
	Pure sea water - - - - - - - -	14	16·8	10	43·3	27·8
	Ammonium chloride (N = 0·025 per 100,000) -	11	16·0	8	42·6	27·1
	Potassium nitrate (N = 0·025 per 100,000) - -	12	9·2	10	19·3	13·8

The method adopted in this table has the advantage of comparing the results under entirely similar conditions, but it has at least two great disadvantages, namely: (1) It involves a relatively small number of experiments; and (2) it does not permit of direct comparison, in many cases, with similar mixtures. Thus by this method it is not possible to compare the growth of *Ulva* in 10 per cent., 25 per cent., and 50 per cent. of tap water (*plus* pure sea water) under the same conditions of seasons, etc. This is done as far as possible in the next table:—

TABLE XXIIA.

EFFECTS OF THE EXTENT OF "BRACKISHNESS" ON THE GROWTH OF *ULVA* AT DIFFERENT SEASONS, CONTRASTED WITH THE EFFECTS OF SEWAGE, SPRINKLER EFFLUENT AND PURE SEA WATER.

(AVERAGE PER CENT. INCREASE IN AREA.)

	1910.			1909 to 1910.	
	June.	July.	August.	September to October.	October to March.
Sewage	64·5 (10)	126·7 (19)	80·9 (20)	—	—
Sprinkler effluent	82·5 (10)	84·3 (14)	80·7 (18)	—	—
Pure sea water	21·5 (4)	33·2 (5)	36·5 (8)	—	—
10 per cent. tap water	40·4 (8)	27·8 (5)	25·2 (6)	—	—
Sewage	64·5 (10)	126·7 (19)	—	41·7 (12)	10·7 (12)
Sprinkler effluent	82·5 (10)	84·3 (14)	—	50·5 (11)	8·8 (12)
Pure sea water	21·5 (4)	33·2 (5)	—	53·9 (8)	15·0 (8)
25 per cent. tap water	38·7 (8)	73·7 (3)	—	54·5 (4)	15·2 (4)
Sewage	—	—	—	41·7 (12)	10·7 (12)
Sprinkler effluent	—	—	—	50·5 (11)	8·8 (12)
Pure sea water	—	—	—	53·9 (8)	15·0 (8)
50 per cent. tap water	—	—	—	58·5 (8)	22·9 (8)

Note.—The figures in brackets show the number of experiments made with Cut Squares and Whole Fronds combined.

All three methods of comparison agree in showing that *Ulva* can grow in highly brackish water, and on the whole they also show that the extent of growth in such mixtures is greater than in pure sea water.

The effects of the seasons are interesting. Thus in the experiments with 10 per cent. tap water, which were all made in the summer months, it will be seen: (1) That the stimulating effects of both the sewage and sprinkler effluent were much greater than those of the tap water. Also (2) the results indicate that while the stimulating effects of the sewage *increased* from June to August, those of the tap water *decreased.*

The experiments with the 25 per cent. tap water mixtures were made partly during the summer, and partly during the autumn and winter months. It will be seen that as in the case of the 10 per cent. mixtures: (1) The stimulating effects of the sewage were much greater than those of the tap water; while (2) that unlike the 10 per cent. mixture, stimulation by the tap water appears to have *increased* from June to July. But it may be stated that this was almost entirely due to the growth of one whole frond, and if that of the cut squares alone be taken into consideration, the average figures for June and July are respectively 27·5 and 20, and are then in harmony with the results of the 10 per cent. experiments. However, the available data are entirely insufficient to form any definite decisions on this point.

The experiments with the 50 per cent. tap water mixtures were made entirely during the autumn and winter months. The results are generally in accord with those obtained during the same period with the 25 per cent. mixtures, but the increased brackishness appears to have enhanced the effects. On the whole, we are of the opinion that the experiments justify the conclusion that in summer, sewage stimulates the growth of *Ulva* to a much greater extent than either brackish or pure sea water, but that in the autumn and winter the reverse is the case.*

Effects of Chemical Stimulants.—The chief effects of such purely chemical substances as we have tried (dissolved in pure sea water) are shown in two of the tables already given.

The greatest stimulation appears to have been caused by the weak ammonium chloride solutions (nitrogen content equivalent to 1 per cent. Belfast sewage)—both alone and with added sodium phosphate, *plus* ferrous sulphate; the stimulation being (from the experiments) practically the same in both cases, and therefore probably due to the ammonium salt only.

It may however be argued that these mixtures had *no* stimulating effects at all on the growth of *Ulva*, the corresponding figures both for the former and for pure sea water being almost identical, and the trifling advantage on the side of the sea water.

The effects of potassium nitrate (in pure sea water)—of equal nitrogen content to that of the ammonium chloride mixtures, were remarkably less than those of the latter (practically one half)—a result which is therefore in harmony with the views expressed by one of us in his Reports to the Belfast Corporation, that nitrogen in the form of nitrates is by no means so potent a food stuff for *Ulva* as nitrogen in the form of ammonium salts.

The slight stimulation (or want of stimulation) by ammonium chloride was unexpected, in view of the experiments described in Appendix VI. to the Commission's Fifth Report on the remarkable power which *Ulva* undoubtedly possesses of absorbing ammonia from solutions of ammonium chloride in sea water, and the question arises as to whether the conditions were exactly similar in the two sets of experiments. Undoubtedly there was one point of difference, namely, that in the assimilation experiments, the *polluted water of Belfast Lough* was used, while in those on growth, *pure sea water* was employed.*

It is clear from the experiments which we have made for the Commission that *Ulva* thrives during its growing period in mixtures containing a high proportion of sewage, and also that its nitrogen content increases after growth in such mixtures.

Further, we may we think assume (in accordance with the teachings of plant physiology) that the nitrogenous food stuff which it absorbs from sewage is ammonia, in the form either of free ammonia or in that of ammonium salts.

The suggestion may therefore be made—as at least worthy of consideration—that sewage contains some stimulant, possibly of a chemical, or possibly of a bacterial nature which excites the activity of *Ulva* as regards food assimilation.

We regret that it is now too late for the purposes of this Report to test the matter experimentally.

This might be done by making two parallel and simultaneous series of experiments on the growth of *Ulva*; (*a*) in solutions of ammonium chloride in pure sea water; and (*b*) in solutions, of corresponding nitrogen content, of the same salt in water from Belfast Lough.

The following table may be of service in contrasting the growth of *Ulva* during corresponding periods (as measured by average percentage increase in area) under the different conditions of our experiments. It brings out some of the facts already mentioned, such as the small growth in the imitation tidal experiments compared with the large growth in the timber pond channel bay and the intermediate growth in the glass dishes.

Unfortunately, owing to the number and variety of experiments which were simultaneously in progress and which demanded constant attention, it is very incomplete and a full contrast it will be seen is only possible during one month—(August):—

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* That is to say, under experimental conditions.

* For later experiments on this point, *see* p. 118.

TABLE XXIII.—GROWTH OF *ULVA* DURING CORRESPONDING PERIODS, UNDER DIFFERENT CONDITIONS.

Average Per Cent. Increase in Area.

			1909.		1910.		
			June. (2 Weeks.)	July. (3 Weeks.)	June. (4 Weeks.)	July. (4 Weeks.)	August. (4 Weeks.)
(1) Imitation tidal experiments.	Pure seawater.	Cut squares	—	—	—	—	7·5 (2)
		Whole fronds	—	—	—	—	52·5 (2)
	Polluted mixtures.	Cut squares	—	—	—	—	8·5 (4)
		Whole fronds	—	—	—	—	41·3 (4)
(2) Glass dish experiments.	Pure seawater.	Cut squares	—	—	26 (2)	18·7 (4)	16·5 (4)
		Whole fronds	—	—	17 (2)	91 (1)	56·5 (4)
	Polluted mixtures.	Cut squares	67 (2)*	134 (7)*	86·6 (10)	47·5 (20)	53·6 (18)
		Whole fronds			69·2 (10)	203 (13)	105·2 (20)
				June. (3 Weeks.)	June to July. (4 Weeks.)		
(3) Timber Pond Channel Bay experiments.		Cut squares	196 (6)*	334 (4)*	219 (8)		158 (4)
		Whole fronds			182 (5)		234 (9)

Note.—The figures in brackets refer to the number of experiments made in each series.

* The figures refer to the results of the experiments on cut squares and whole fronds combined.

GROWTH OF *ULVA* IN RELATION TO INCREASE OR DECREASE IN ITS WEIGHT PER UNIT OF AREA OR SURFACE.

Fairly early in our investigations, it occurred to us that just as a human being or a tree may be said to grow in two different ways, namely: (*a*) By an increase in height, and (*b*) by an increase in bulk, so might *Ulva* increase: (*a*) in area; and (*b*) in weight per unit of surface or area; also that the "fattening" of the seaweed in the latter case might be associated with the nature and amount of its food supply, and again quite possibly with its nitrogen content. In our experiments on these points, the area of the *wet* fronds was alone taken into consideration. This was measured in the case of new leaves (*i.e.*, new for experimental purposes) by cutting out a square of given dimensions (usually 3 inches by 3 inches) from a larger frond with a sharp pen knife.

But in the case of leaves which had been growing for some time under experiment, the original square shape generally became distorted and the measurement of area was then made by placing a given leaf on a sheet of ground glass and running a pencil point round its margin. The tracing was then transferred to paper and the area measured with a planimeter. The leaf was then rinsed in fresh water, dried at 100° C. until of constant weight, and from the data thus obtained the weight per square inch calculated. Also in some cases a determination of nitrogen was made in the dried material.

The following table contains a summary of the results obtained, together with some other particulars :—

TABLE XXIV.—WEIGHT OF *ULVA* PER SQUARE INCH OF SURFACE, ETC.

GLASS DISH EXPERIMENTS.

Mixture.	Series.	Period.	Average per cent. Increase in Area.	Average per cent. Increase or Decrease in Weight Per Square Inch.	Average per cent. Increase or Decrease in Nitrogen Content.
Sewage mixtures - - -	3	1909—July to August (4 Weeks.)	118 (5)	+ 54	+ 0·38
Sprinkler effluent mixtures -	3	,,	137 (5)	+ 33	+ 0·17
Pure seawater - - -	3	,,	46 (1)	− 25	− 2·44
Sewage mixtures - - -	5	September to October (4 Weeks.)	16 (6)	+ 16	+ 0·81
Sprinkler effluent mixtures -	5	,,	23 (5) 13 (1)	+ 13 − 15	+ 0·41 + 1·55
Pure seawater - - -	5	,,	28 (4)	+ 25	− 0·55
Sewage mixtures - - -	7	1910—June (4 Weeks.)	94 (5)	+ 33	No determinations.
Sprinkler effluent mixtures -	7	,,	78 (5)	+ 37	,,
Pure seawater - - -	7	,,	26 (2)	+ 31	,,

It will be seen that the results are of a contradictory nature. Taking only the average figures :—

In Series 3 there was a considerable increase in weight per unit of surface in the polluted mixtures and a gain in nitrogen. While in the pure seawater there was a considerable decrease in both factors. In Series 5 there was an increase in weight per unit of surface in both the polluted mixtures and in the pure seawater, a gain in nitrogen in the former but a loss in the latter.

The results of Series 7 resemble those of Series 5, except that no determinations of nitrogen were made.

TIDAL TANK EXPERIMENTS. (SERIES 12 AND 13.)

CHANGES IN WEIGHT AND IN NITROGEN CONTENT.

The following experiments were made in order to see how *Ulva* varied in weight when grown in some quantity in polluted water, compared with the variations in a similar weight of wet weed placed in pure seawater. The experiments were carried out in the stoneware tidal tanks described on p. 74.

In Experiment 12, three tanks were used.

No. 1 was fed with pure seawater.

No. 2 was fed with pure seawater, plus 5 per cent. sewage.

No. 3 was fed with pure seawater, plus 1 per cent. sewage, plus 19 per cent. tapwater.

Eight ounces of wet *Ulva* were placed in each tank. To get as uniform weight as possible all the *Ulva* was handled in a special way before weighing. Each frond was lifted, opened out, held until it ceased to drip and then placed on one side. When the necessary amount of weed had been prepared the quantities for each tank were rapidly weighed out.

The experiment was started on June 1st and weighings were made at intervals. Small samples were also removed every 14 days for estimation of nitrogen.

The mixture in tank No. 3, viz., pure seawater with 1 per cent. sewage, and 19 per cent. tap water, was intended to imitate the average composition of the water flowing over the *Ulva* banks on the County Down foreshore, as found in the series of samples described on p. 103.

TABLE XXV.—WEIGHT OF *ULVA* IN TIDAL TANKS.

SERIES No. 12.

	Tank No. 1. Pure Seawater.	Tank No. 2. Pure Seawater plus 5 per cent. Sewage.	Tank No. 3. Pure Seawater plus 1 per cent. Sewage and 19 per cent. Tap water.
June 1st - - - - - - - - -	8·0 ozs.	8·0 ozs.	8·0 ozs.
,, 17th - - - - - - - - -	5·5 ,,	10·7 ,,	8·1 ,,
,, 29th - - - - - - - - -	5·5 ,,	10·8 ,,	9·1 ,,
July 8th - - - - - - - - -	5·0 ,,	9·6 ,,	8·0 ,,
,, 17th - - - - - - - - -	6·2 ,,	11·0 ,,	10·0 ,,
,, 28th - - - - - - - - -	5·9 ,,	11·0 ,,	8·3 ,,

TABLE XXVa.—NITROGEN ESTIMATIONS MADE EVERY FOURTEEN DAYS.

	Tank No. 1. Pure Seawater. Per cent. nitrogen in *dry* seaweed.	Tank No. 2. Pure Seawater plus 5 per cent. Sewage. Per cent. nitrogen in *dry* seaweed.	Tank No. 3. Pure Seawater plus 1 per cent. Sewage and 19 per cent. Tap water. Per cent. nitrogen in *dry* seaweed.
June 1st	4·75	4·75	4·75
„ 16th	4·68	4·71	5·06
July 1st	4·33	4·79	4·36
„ 16th	4·62	4·42	—
„ 28th	4·63	5·35	5·38

At the end of this period of eight weeks the condition of the weed in the tanks was as follows :—

No. 1. Rather thin and sticky—not decayed.
No. 2. Quite green and crisp.
No. 3. Very slimy—beginning to decay.

In view of the 90 per cent. of water held by the *Ulva* when weighed, the figures given cannot be taken as accurate to, possibly, 1 ounce, but with the large number of weighings made, this error will not affect the conclusion which has already been drawn from the glass dish experiments, viz., that sewage pollution causes a marked increase in weight of *Ulva* compared with that grown in pure seawater.

It will be noticed that practically all the changes in weight occurred in the first fifteen days. As the fall in weight in the case of the pure seawater was so striking, it was considered well to repeat this experiment in duplicate.

Series 13.

Each tank was now given only 4 ounces of weed instead of 8 ounces. This was done for two reasons :—

(1) The tanks were rather overcrowded with 8 ounces.

(2) It was a very tedious business to drain some 100 fronds in this way.

Two more tanks were used in this experiment, the extra ones being fed with pure seawater and a mixture of pure seawater and 20 per cent. tap water.

TABLE XXVI.

	Tank Nos. 1 and 5. Pure Seawater. Weight of *wet* seaweed.		Tank No. 2. 5 per cent. Sewage. Weight of *wet* seaweed.	Tank No. 3. 1 per cent. Sewage, 19 per cent. Tap water. Weight of *wet* seaweed.	Tank No. 4. 20 per cent. Tap water. Weight of *wet* seaweed.
July 26th	4·0	4·0 ozs.	4·0 ozs.	4·0 ozs.	4·0 ozs.
September 10th	3·7	3·7	4·5	5·2	4·6
„ 29th	3·3	3·6	4·4	4·7	4·6

The weed in Tanks 1 and 2 was the same as that previously used in these tanks in experiment 12, while the other tanks were filled with fresh weed from the sloblands.

In pure seawater the new and old weed behaved in the same way—there was a small drop in weight in both.

The other tanks all showed an increase, the greatest being in No. 3.

The rate of growth in these tidal tanks is very slow compared with that in glass dishes and still more with that under natural conditions as shown in the Timber Pond Bay experiments. At the rates observed in the latter cases, the 4 ounces would have become 12 to 16 ounces in the case of the polluted water, while the loss in weight in the pure seawater would possibly have been changed to a slight gain of 1 or 2 ounces.

The following summary of the experiments may be given :—

TABLE XXVII.—TIDAL TANK (WEIGHT) EXPERIMENTS.

		WEIGHT.			NITROGEN CONTENT.		
		Original Weight.	Final Weight.	Per cent. Gain or Loss.	Original per cent.	Final per cent.	Per cent. Gain or Loss.
5 per cent. sewage	June to July (8 Weeks.)	8·0 oz.	11·0 oz.	+ 37·5	4·75	5·35	+ 0·60
1 per cent. sewage + 19 per cent. tap water	„	8·0 „	8 3 „	+ 3·7	„	5·38	+ 0·63
Pure seawater	„	8·0 „	5·9 „	– 26·2	„	4·63	– 0·12
5 per cent. sewage	Aug. to Sept. (2 Months.)	4·0 „	4·4 „	+ 10·0	—	—	—
1 per cent. sewage + 19 per cent. tap water	„	4·0 „	4·7 „	+ 17·5	—	—	—
20 per cent. tap water	„	4·0 „	4·6 „	+ 15·0	—	—	—
Pure seawater	„	4·0 „	3·3 „	– 17·5	—	—	—
„ „	„	4·0 „	3·6 „	– 10·0	—	—	—

The tidal tank experiments are in our opinion of considerable importance as (relatively) large quantities of the seaweed were employed and therefore an important source of error avoided. In both series, the results are unmistakable, *Ulva* (from the co. Down slobland) *lost* weight in pure seawater but *gained* weight in the polluted mixtures also in the first set of these experiments, this was attended with a *loss* and a *gain* in nitrogen respectively. In these (weight) experiments the area was not measured, as it would have involved too great an expenditure of time, but we think that the following argument is sound.

If the area in the particular experiments had increased, the weight per unit of surface must have *decreased*, also if it remained stationary the same thing must have happened. Only on the highly improbable hypothesis of a shrinkage in area could the weight per unit of surface have *increased*.*

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* For some other weight experiments *see* p. 119.

GENERAL CONCLUSIONS.

It is difficult to give a general summary which shall group together all the different experiments and present the salient features emerging from the results in their correct proportions.

We have already explained some of the difficulties which have been encountered during our experiments on the growth of *Ulva* and we need not again refer to them.

We believe, however, that the results of our experiments warrant the following general conclusions :—

(1) *Ulva* (as collected from Belfast Lough) can grow in pure sea water and in the colder months, when the activity of its growth is rapidly diminishing or is almost stationary, such growth as occurred was greater in pure seawater than in mixtures of the same with sewage or with sprinkler effluent.

(2) During the period of its active growth (warmer season of the year) the effects of sewage pollution (or those of sprinkler effluent) are very considerable.

These effects reach their maximum at Belfast about July or August, the exact period no doubt varying somewhat with the temperature. In our (Glass Dish) experiments in 1910 the maximum growth was in July, when in the mixtures of sewage and sea water it amounted in round numbers to four times as much as that in pure sea water.

We think that no surprise need be felt at such a result as it is not only in accordance with the principles of plant physiology, but also with the practice of the Agriculturalist. Our experiments (Glass Dish) were made under very artificial conditions, and it is conceivable that the stimulating effects of sewage or of sprinkler effluent are even greater under natural conditions. The experiments in the timber pond channel bay (*see* Table XIV.) lend support to this view, but we have no direct evidence to enable us to contrast the rate of growth of *Ulva* in pure sea water, under natural conditions, with that in polluted waters under the same conditions.

It is, however, remarkable that in two series of experiments in which considerable quantities of *Ulva* (from Belfast) were grown both in pure seawater and in a mixture of the same with 5 per cent. sewage, the sea-weed *lost* weight in the pure seawater to the extent of over 20 per cent., while in the polluted mixture it gained over 23 per cent. in weight during the same period (June to September). Further, there was a loss and a gain in nitrogen content in the pure and polluted seawater, respectively.

(3) As regards "Brackishness," we have already drawn attention to its stimulating effects; but whether these are due to the fresh water itself or to its nitrogenous constituents we have not had time to decide. This, of course, could be done by means of experiments in which pure distilled water was substituted for tap water.

(4) In our experiments with chemical stimulants (*e.g.*, ammonium salts, nitrates, phosphates, &c.), no increase of the *Ulva*'s growth was produced in mixtures of these with pure sea water. Therefore (as we have elsewhere mentioned) it seems probable that a stimulant of some kind (chemical or bacterial) is required in addition, to induce growth.

3.—THE AMOUNTS OF NITROGEN, SULPHUR, PHOSPHORUS AND ASH IN *ULVA LATISSIMA* AND IN SOME OTHER GREEN SEAWEEDS.

A considerable number of samples of *Ulva* collected in Belfast Lough and from other places have been analysed with the object of ascertaining as far as possible whether the composition of this seaweed varied with its environment, as suggested on p. 148 of Appendix VI. to the Commission's Fifth Report.

The nitrogen content has been determined in all these samples, the ash in the majority and sulphur as well as phosphorus in a few specially selected samples. If time had permitted, it would have been desirable to determine the last two of these constituents in several more samples, but this, unfortunately, could not be done.

In Table XXVIII. we have collected the figures for nitrogen and ash in samples of *Ulva** and some other green seaweeds, as gathered from different localities under natural conditions.

The Belfast samples were nearly all gathered from the Connswater and Tillysburn doblands, the waters flowing over which, as we show elsewhere,† are polluted to the extent of about 1 per cent. with the sewage of Belfast (as measured by the ammoniacal nitrogen).

In Table XXIX. we have collected the relatively few figures which we have been able to obtain for the contents of nitrogen, sulphur and phosphorus in some of the samples. And here it may be remarked that while determinations of nitrogen can be made in a relatively short time and easily, those of sulphur and phosphorus are far more difficult and demand an expenditure of time amounting to two or three days for each analysis, as well as constant attention, if the results are to have a real value.

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* Determinations of nitrogen and ash in samples of *Ulva* grown under artificial conditions are given in Tables XXXI.-XXXII. (pp. 95-97).

† *See* pp. 99-104.

TABLE XXVIII.—NITROGEN AND ASH IN *ULVA* AND SOME OTHER GREEN SEAWEEDS.

FRESHLY GATHERED FROM DIVERSE LOCALITIES.

(RESULTS EXPRESSED AS PERCENTAGES ON THE DRIED SEAWEEDS.)

(1) ULVA LATISSIMA.

	Nitrogen.	Ash.
Belfast Lough, Frond No. 1 -	4·99	16·02
„ „ „ 2 -	3·74	30·99
„ „ „ 3 -	3·44	34·27
„ „ „ 4 -	3·72	32·92
„ „ „ 5 -	3·75	12·14
„ „ „ 6 -	3·80	14·62
„ „ „ 7 -	3·39	15·37
„ „ „ 8 -	3·19	28·01
„ „ „ 9 -	4·41	17·99
„ „ „ 10 -	4·23	17·89
„ „ „ 11 -	3·96	16·84
„ „ „ 12 -	4·59	17·67
Comber, Co. Down - - -	3·97	16·77
Brancaster, Norfolk - - -	3·21	17·78
Exmouth, Devon - - -	3·73	14·17
Starcross, Devon - - -	3·65	11·78
Clare Island, Co. Mayo - -	1·73	25·05
Durlston Bay, Dorset - -	1·13	22·63
Studland Bay, Dorset - -	1·18	17·92

(2) ENTEROMORPHA.

Strangford Lough (*E. Prolifera**)	3·77	19·28
„ „ (Ditto. decaying	1·18	15·96
Comber, Co. Down (*E. Prolifera*) -	4·38	19·32
„ „ (*E. Intestinalis*	3·97	22·99
Ganavan, Oban, N.B. (*E. Intestinalis*) - - - - - -	1·13	27·72

* "May Fog." *See* p. 104.

TABLE XXIX.—NITROGEN, SULPHUR AND PHOSPHORUS IN *ULVA* AND SOME OTHER GREEN SEAWEEDS.

(RESULTS EXPRESSED AS PERCENTAGES ON THE DRIED SEAWEED.)

(1) ULVA LATISSIMA.

Belfast Lough.

	I.	II.	III.	IV.	V.
Nitrogen - -	3·80	4·31	4·75	4·30	3·39
Sulphur - - -	4·06	4·00	5·42	4·42	4·24
Phosphorus - -	0·18	0·28	0·23	—	—

ULVA LATISSIMA.—*continued.*

	Brancaster.	Strangford Lough. (Attached.)	Strangford Lough. (Loose.)
Nitrogen - -	3·21	1·65	2·29
Sulphur - -	4·15	2·21	3·87
Phosphorus -	—	0·12	0·12

	Larne Lough.	Durlston Bay.	Studland Bay.
Nitrogen - -	2·53	1·13	1·18
Sulphur - -	2·63	5·36	5·83
Phosphorus -	0·11	0·10	0·06

(2) ENTEROMORPHA.§

	E. Prolifera. Belfast. Lough.	*E. Prolifera.* Strangford Lough.	*E. Intestinalis.* Ganavan.
Nitrogen - -	4·20	3·77	1·13
Sulphur - -	3·15	4·28	3·47
Phosphorus -	—	—	0·15

(3) MONOSTROMA GREV. (WITT).

	Belfast Lough.		
Nitrogen - -	4·78		
Sulphur - -	3·84	—	—
Phosphorus -	—	—	—

Reviewing the results contained in these two tables, we may first of all mention that our determinations of nitrogen in *Ulva* from localities which we know to be polluted with sewage gave the following results :—

Locality.	Percentage of Nitrogen in the dried *Ulva.*
(1) Belfast Lough (mean) -	3·92 (12 determinations.)
(2) Exmouth (Devon) - -	3·73 (1 „)
(3) Starcross (Devon) - -	3·65 (2 „)
Mean - -	3·77

While those in the same seaweed from localities which we understand are not polluted with sewage gave :—

Locality.	Percentage of Nitrogen in the dried *Ulva.*
(1) Clare Island (Co. Mayo)- - - - - - - - -	1·73 (1 determination.)
(2) Durlston Bay (Dorset) - - - - - - - - -	1·13 (1 determination.)
(3) Studland Bay (Dorset) - - - - - - - - -	1·18 (1 determination.)
(4) Island Mahee (Strangford Lough)† - - - - - -	1·65 (1 determination.)
Mean - - - - - - - - - -	1·42

† A sample of sea water from this place was found on analysis to be less pure than that from the Irish Channel, probably on account of pollution from decaying seaweeds.

It will be seen that the figures are nearly as 3 to 1.

A sample from Larne Lough (which latter is probably slightly polluted with sewage) gave an intermediate quantity, namely, 2·53.‡

Our own experience is that the appearance, thickness and size of the fronds of *Ulva* taken at the same season from polluted and unpolluted localities respectively, are different.

The seaweed from unpolluted localities has an apple-green colour and the fronds are usually thin and small

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§ Before the Commission had taken up the question of *Ulva* and green seaweeds in relation to pollution, one of us in collaboration with Mr. C. R. Crymble (Senior Assistant in Chemistry in the Queen's University of Belfast) had analysed two samples of *E. Linza*, of which the first was collected from the slobland near the mouth of the Connswater River (near the position marked 2 on the map accompanying this Report) and was therefore from a polluted locality, while the other was taken from Brown's Bay, near Larne, which they believe to be free from sewage pollution. The following results were obtained :—

E. Linza. (?)

	Near mouth of Connswater, (Polluted.)	Brown's Bay. (Unpolluted.)
Nitrogen - - - -	5·78 - - -	3·85
Sulphur - - - -	2·55 - - -	3·67
Phosphorus - - -	0·45 - - .	0·30

‡ A specimen from the same locality analysed some years ago was found to contain 3·01 per cent.

While that from polluted districts is dark green and the fronds thicker and very much larger.

Reverting again to the nitrogen content of *Ulva*, we have not found in samples grown under natural conditions in polluted waters a higher amount than 5·22 per cent. during our joint work at Belfast, but some years previously one of us examined a sample which was found to contain 6·18 per cent.

In artificial cultures as we shall show presently, a figure as high as 6·54 per cent. was obtained. (See Table XXXI.).

In our opinion, the nitrogen content of *Ulva* grown under natural conditions is of importance in relation to the general problem under discussion in this Report.

Regarding the contents of sulphur and phosphorus, as well as the ratios of these to the nitrogen present in addition to these two elements, it will be seen from Table XXIX., that in *Ulva* the variations in sulphur are nearly as great as those in nitrogen, namely from 2·63 to 5·83, while the variations in phosphorus are from 0·06 to 0·28, and the amount of the latter in the Belfast specimens is broadly speaking twice as great as that of the samples from the unpolluted or slightly polluted localities.

The ratios of the three elements to each other are as follows:—

TABLE XXX.

	N.	S.	P.
Ulva.			
Belfast Lough. Sample No. 1 -	100	107	5
,, ,, ,, ,, 2 -	100	93	6
,, ,, ,, ,, 3 -	100	114	5
,, ,, ,, ,, 4 -	100	103	—
,, ,, ,, ,, 5 -	100	125	—
Brancaster - - - - -	100	129	—
Strangford Lough (attached) -	100	134	7
,, ,, (loose) - -	100	169	5
Larne Lough - - - - -	100	104	4
Durlston Bay - - - - -	100	475	9
Studland Bay - - - - -	100	503	5
*Enteromorpha.**			
Belfast Lough (*E. prolifera*) -	100	75	—
Strangford Lough (*E. prolifera*)	100	114	—
Ganavan Strand (near Oban, N.B.) (*E. intestinalis*) - -	100	307	13

Speaking very broadly, a high ratio of sulphur to nitrogen in the cases of both *Ulva* and *Enteromorpha* is found in samples from unpolluted districts (and very notably in those from Durlston, Studland and Ganavan). It will be seen that with two exceptions the ratio of nitrogen to phosphorus is fairly constant. The two exceptions are Durlston and Ganavan—both unpolluted localities, the samples of green sea-weeds from which are remarkable for their low nitrogen content.

Regarding the proportion of ash in *Ulva*, the results are most variable, and as yet we have obtained no clue to the cause or causes of these variations.

In the 12 samples of *Ulva* from Belfast Lough (of which the analyses are given in Table XXVIII.) the percentage of ash varies from 12·14 to 34·27, or roughly in the ratio of 1 to 3.

The variations of ash in *Ulva* grown under artificial conditions (see Table XXXI.) are quite as remarkable and inexplicable.

Green sea-weeds other than Ulva.—It will be seen from the tables that while only a few of these have been examined it appears probable that *Monostroma* and *Enteromorpha* in their different varieties resemble *Ulva* in their contents of nitrogen, sulphur and phosphorus, and appear to show similar variations in these according to their environment. *E. prolifera* is specially interesting in this respect because of the nuisance caused by its decay in a bay at Island Mahee, Strangford Lough, where there is no sewage pollution.

Distribution of nitrogen in the tissues of Ulva.—The following experiment was made in order to get some information on this point:—

A piece of *Ulva* (about 20 square inches), was boiled first with distilled water for two minutes, then with alcohol until bleached, the chlorophyll being thus completely removed. Estimations of nitrogen (Kjeldahl) were then made (1) on the aqueous extract, (2) on the alcoholic extract (chlorophyll) and (3) on the insoluble residue. The results were as follow:—

	Grammes N.	Per cent. N. (on total N.)
Aqueous extract - -	0·00198	16·77
Alcoholic extract - -	0·00052	4·45
Residue - - - - -	0·00921	78·78
	—	100·00

From which it appears that the bulk of the nitrogen present in the tissues of *Ulva* is in the form of insoluble proteid.

Distribution of sulphur in the tissues of Ulva.—An examination of *Ulva* from Belfast Lough (Sample No. 7) was made with the object of ascertaining how much of the sulphur present in it was in the form of sulphate (inorganic) and how much in that of proteids (organic). The sample was first extracted for one hour in the cold with 5 per cent. hydrochloric acid. The extract containing the sulphates and a certain amount of "soluble proteid" was filtered and precipitated with barium chloride.

The insoluble residue was oxidised with strong nitric acid, boiled with water, etc., and the solution so obtained also treated with barium chloride, the sulphur found in the resulting precipitate being reckoned as due to "insoluble proteid."

While the sulphur present as "soluble proteid" was arrived at by subtracting the sum of the sulphur obtained as above from the total sulphur as determined by the method given on p. 120.

A similar series of determinations was made on a sample of *Ulva* from Studland Bay.

The figures for the two samples are given below:—

	Belfast Lough. (Polluted with sewage.)	Studland Bay. (Dorset.) (No sewage.)
Sulphur as Sulphate - -	1·40	3·55
Soluble proteid	1·50	1·17
Insoluble proteid - -	1·34	1·11
Total - -	4·24	5·83

As before mentioned, the sample of pure water *Ulva* contains a higher proportion of total sulphur than that from the polluted water of Belfast Lough. The excess, however, is entirely due to sulphate, for the organic or proteid sulphur is distinctly less than in the *Ulva* from the polluted water.

These sulphur figures may be of importance when the question of nuisance caused by the decay of the weed is under consideration. From the figures it is at least possible that *Ulva* grown in pure sea water can give rise to a nuisance as great as that arising from the weed grown in the polluted water of Belfast Lough, provided, of course, that the quantities are the same (see p. 119).

It must, however, be borne in mind that the sea-water held up by *Ulva*, lying on the shore, contains a considerable quantity of sulphates and the sulphur in this form has been proved experimentally to be easily converted into sulphuretted hydrogen by definite organisms which occur in foul marine mud.

The actual sulphur content of dry *Ulva* may thus be of minor importance, but we are at present unable to state which of the two sources of sulphur is the more likely to determine the magnitude of the nuisance.

Amounts of Nitrogen and Ash in Ulva grown under artificial conditions.—In the following table we have collected our determinations of nitrogen and ash in *Ulva* grown under artificial conditions both in pure seawater as well as in various polluted mixtures of the same:—

---

* Ratios for *E. Linza* described in footnote p. 93:—

	N.	S.	P.
Connswater sample - - - -	100	44	7·9
Brown's Bay ,, - - - -	100	98	7·7

TABLE XXXI.—ESTIMATIONS OF TOTAL NITROGEN BY KJELDAHL AND OF ASH IN *ULVA* GROWN IN VARIOUS MIXTURES. RESULTS STATED AS PERCENTAGE WEIGHTS ON THE DRY WEED.

GLASS DISH EXPERIMENTS.

Cut Squares.

Mixture.	Period of Growth.	Month.	Original Per Cent. of Nitrogen.	Per Cent. Nitrogen found at end of Experiment.	Original Per Cent. Ash.	Per Cent. Ash found at end of Experiment.
1 per cent. sewage	4 weeks.	July to August.	4·99	3·66	16·08	11·71
5 " "	4 "	" "	4·99	4·87	16·08	13·46
10 " "	4 "	" "	4·99	5·57	16·08	12·86
20 " "	4 "	" "	4·99	6·54	16·08	12·28
30 " "	4 "	" "	4·99	6·20	16·08	13·85
1 per cent. sprinkler effluent	4 "	" "	4·99	3·86	16·08	15·28
5 " " "	4 "	" "	4·99	5·22	16·08	16·32
10 " " "	4 "	" "	4·99	5·13	16·08	13·29
20 " " "	4 "	" "	4·99	5·99	16·08	13·04
30 " " "	4 "	" "	4·99	5·59	16·08	14·49
Pure seawater	4 "	" "	4·99	2·55	—	—
1 per cent. sewage	3 "	August to September.	3·81	5·75	14·62	9·33
5 " "	3 "	" "	3·81	—	14·62	—
10 " "	3 "	" "	3·81	5·13	14·62	9·97
20 " "	3 "	" "	3·81	5·13	14·62	10·30
30 " "	3 "	" "	3·81	4·30	14·62	8·84
1 per cent. sprinkler effluent	3 "	" "	3·81	4·59	14·62	5·51
5 " " "	3 "	" "	3·81	4·89	14·62	8·91
10 " " "	3 "	" "	3·81	4·86	14·62	4·33
20 " " "	3 "	" "	3·81	5·35	14·62	10·53
30 " " "	3 "	" "	3·81	5·74	14·62	7·25
Pure seawater	3 "	" "	3·81	4·62	14·62	8·56
" "	3 "	" "	3·81	4·03	14·62	8·44
Seawater over sludge	3 "	" "	3·81	3·81	14·62	20·91
1 per cent. pot ale	3 "	" "	3·81	4·48	14·62	8·65
Ammonium chloride (N = 2·5 per 100,000)	3 "	" "	3·81	4·77	14·62	8·87
" " (N = 0·025 per 100,000)	3 "	" "	3·81	4·93	14·62	8·15
Potassium nitrate (N = 2·5 per 100,000)	3 "	" "	3·81	5·17	14·62	8·04
" " (N = 0·025 per 100,000)	3 "	" "	3·81	4·77	14·62	8·13
Ammonium chloride + sodium phosphate (N = 2·5 per 100,000)	3 "	" "	3·81	5·11	14·62	8·63
" " + " " (N = 0·025 per 100,000)	3 "	" "	3·81	5·51	14·62	7·63
Potassium nitrate + sodium phosphate (N = 0·025 per 100,000)	3 "	" "	3·81	4.93	14·62	7·79
1 per cent. sewage	4 "	September to October	4·46	5.78	17·99	12·25
1 " " (in shade)	4 "	" "	4·46	5.17	17·99	—
5 " "	4 "	" "	4·46	4.69	17·99	11·65
5 " " (in shade)	4 "	" "	4·46	5.45	17·99	—
1 per cent. sprinkler effluent	4 "	" "	4·46	4.68	17·99	11·13
1 " " " (in shade)	4 "	" "	4·46	4·76	17·99	—
5 " " "	4 "	" "	4·46	5·04	17·99	13·43
5 " " " (in shade)	4 "	" "	3·96	5·51	16·84	—
Pure seawater	4 "	" "	3·96	3·18	16·84	10·61
" " (in shade)	4 "	" "	3·96	3·64	16·84	9·61
75 per cent. pure seawater + 25 per cent. tap water	4 "	" "	3·96	3·43	16·84	8·35
75 " " " + 25 " " " (in shade)	4 "	" "	3·96	5·53	16·84	—
50 " " " + 50 " " "	4 "	" "	3·96	3·70	16·84	9·24
50 " " " + 50 " " " (in shade)	4 "	" "	3·96	3·71	16·84	9·46
Ammonium chloride (N = 0·025 per 100,000)	4 "	" "	3·96	4·02	16·84	9·48
" " (N = 0·025 per 100,000) (in shade)	4 "	" "	3·96	5·49	16·84	10·43
Potassium nitrate (N = 0·025 per 100,000)	4 "	" "	3·96	—	16·84	8·89
Potassium nitrate	4 "	" "	3·96	4·95	16·84	15·98
Ammonium chloride + sodium phosphate + ferrous sulphate N and Fe = 0·025 P = 0·0025 per 100,000	4 "	" "	3·96	5·08	16·84	8·99
" " " " " (in shade)	4 "	" "	4·59	4·96	17·67	10·56

TABLE XXXI.—*continued.*

IMITATION TIDAL EXPERIMENTS.

Tank and Mixture.	Period of Growth.	Month.	Original Per Cent. of Nitrogen.	Per Cent. Nitrogen found at end of Experiment.	Original Per Cent. Ash.	Per Cent. Ash found at end of Experiment.
Cut Squares.						
No. 1. Slob Pure seawater	4 weeks.	July to August.	3·72	4·07	32·92	19·28
„ „ Deep „ „	4 „	„ „	3·72	3·95	„	22·03
No. 2. Slob 1 per cent. sewage	4 „	„ „	3·72	4·96	„	15·51
„ „ Deep 1 „ „	4 „	„ „	3·72	6·68	„	22·72
No. 3. Slob 1 per cent. sprinkler effluent	4 „	„ „	3·72	3·36	„	14·22
„ „ Deep 1 „ „ „	4 „	„ „	3·72	3·02	„	22·43
Whole Fronds.						
No. 1. Slob Pure seawater	4 „	„ „	*	4·90	*	16·66
„ „ Deep „ „	4 „	„ „	*	4·03	*	18·25
No. 2. Slob 1 per cent. sewage	4 „	„ „	*	4·51	*	17·84
„ „ Deep 1 „ „	4 „	„ „	*	4·01	*	18·45
No. 3. Slob 1 per cent. sprinkler effluent	4 „	„ „	*	4·69		18·71
„ „ Deep 1 „ „ „	4 „	„ „	*	4·13	*	19·08
WEIGHT EXPERIMENTS—*Whole Fronds.*						
No. 1. Pure seawater	2 „	June to September.	4·75	4·68	—	—
„ „ „ „	4 „	„ „	4·75	4·33	—	—
„ „ „ „	6 „	„ „	4·75	4·82	—	—
„ „ „ „	8 „	„ „	4·75	4·63	—	—
No. 2. 5 per cent. sewage	2 „	„ „	4·75	4·71	—	—
„ „ „ „ „	4 „	„ „	4·75	4·79	—	—
„ „ „ „ „	6 „	„ „	4·75	4·42	—	—
„ „ „ „ „	8 „	„ „	4·75	5·35	—	—
No. 3. 1 per cent. sewage + 19 per cent. tap water	2 „	„ „	4·75	5·06	—	—
„ „ „ „ „ + 19 „ „ „	4 „	„ „	4·75	4·36	—	—
„ „ „ „ „ + 19 „ „ „	6 „	„ „	4·75	—	—	—
„ „ „ „ „ + 19 „ „ „	8 „	„ „	4·75	5·38	—	—
Nos. 1 and 5. Pure seawater	9 „	August to September.	4·63	4·94	—	—
No. 2. 5 per cent. sewage	9 „	„ „	5·35	5·03	—	—
„ 3. 1 „ „ + 19 per cent. tap water	9 „	„ „	—	4·58	—	—

* Not ascertainable.

TABLE XXXII.—GLASS DISH EXPERIMENTS.

SUMMARY OF CHANGES IN NITROGEN CONTENT.

Mixture.	Series.	Period.	Per cent. N. at start.	Average Per cent. N. at finish.	Average increase or decrease in N.
Glass Dish Experiments.					
Sewage mixtures	3	July to Aug. (4 weeks).	4·99	5·35 (5)	+ 0·36
Sprinkler effluent ditto	3	,,	4·99	5·14 (5)	+ 0·15
Pure sea-water	3	,,	4·99	2·55 (1)	− 2·44
Sewage mixtures	4	Aug. to Sept. (3 weeks).	3·815*	5·08 (4)	+ 1·265
Sprinkler effluent ditto	4	,,	3·815	5·09 (5)	+ 1·275
Pure sea-water†	4	,,	3·815	4·32 (2)	+ 0·505
Sewage mixtures	5	Sept. to Oct. (4 weeks).	4·46	5·27 (4)	+ 0·81
Sprinkler effluent ditto	5	,,	4·46 3·96	4·83 (3) 5·51 (1)	+ 0·37 + 1·55
Pure sea-water	5	,,	3·96	3·41 (2)	− 0·55
Imitation Tidal Tank (Area) Experiments.					
Sewage (1 per cent.)	10	July to Aug. (4 weeks).	3·72	5·82 (2)	+ 2·10
Sprinkler effluent (1 per cent.)	10	,,	3·72	3·19 (2)	− 0·53
Pure sea-water	10	,,	3·72	4·01 (2)	+ 0·29
Imitation Tidal Tank (Weight) Experiments.					
Sewage (5 per cent.)	12	June to July (8 weeks).	4·75	5·35 (1)	+ 0·60
Sewage (1 per cent.) + 19 per cent. tap water	12	,,	4·75	5·38 (1)	+ 0·63
Pure sea-water	12	,,	4·75	4·63 (1)	− 0·12

* This figure is probably too low, as after the square for analysis had been removed, the remaining squares were kept for ten days in the polluted water from the Timber Pond Channel and probably gained in nitrogen content.

† One experiment is included of four weeks duration.

Change of Ulva's Nitrogen content in polluted mixtures.—The general conclusions to be drawn from this table are, we think, (1) that Belfast *Ulva* grown in the polluted mixtures, increased in nitrogen content and sometimes very considerably. (*E.g.* by 2·10, series 10 and 1·275, series 4). Some increase occurred in *all* the experiments with the sewage mixtures, and in all but one of those with sprinkler effluent. The solitary exception is to be found in series 10 (Imitation Tidal Experiments) in the case of a 1 per cent. mixture, when a fall of 0·51 per cent. nitrogen was found. Whatever the explanations may be, experience had certainly taught us that *Ulva* grew much less vigorously under the conditions of these (Imitation Tidal Experiments) than in those of any of the other methods employed.

Change of Ulva's Nitrogen content in pure seawater.—(2) *Ulva* (from Belfast Lough) grown in pure sea-water decreased in nitrogen content* in three and possibly in four of the five sets of experiments. (See footnote to series 4, above.) An increase was observed in series 10 (where the anomalous sprinkler effluent result was obtained) and with less certainty in series 4.

If it be assumed that *Ulva* of the high nitrogen content found in the Belfast Lough samples loses nitrogen when grown in pure sea-water, such loss would be in harmony with our analyses of *Ulva* from unpolluted localities, but in none of our experiments was the nitrogen reduced to the low percentage found in these samples (Mean 1·42) the nearest approach being 2·55 (from 4·99) series 3.

It would be a most interesting experiment to transplant a quantity of *Ulva* from Belfast Lough to an unpolluted locality, and to determine nitrogen in it from time to time during the period of vigorous growth (or rather during the time when growth is most vigorous in Belfast Lough)—say from the beginning of June to the end of August, or possibly somewhat later.

Effects of other substances added to pure sea-water on the nitrogen content of Ulva.—These are collected in the following table :—

---

* Greatest in series 3 (2·44) and series 5 (0·78).

TABLE XXXIII.—GLASS DISH EXPERIMENTS.

Mixture.	Series.	Period.	Per cent. N. at start.	Average per cent. N. at finish.	Average increase or decrease in N.
Sea-water over sludge - - - - - -	4	Aug. to Sept. (4 weeks).	3·815	3·81 (1)	0
1 per cent. pot ale - - - - - -	4	,,	3·815	4·48 (1)	+ 0·665
Ammonium chloride N = 2·5 per 100,000 -	4	,,	3·815	4·77 (1)	+ 0·995
,, ,, N = 0·025 ,, 100,000 -	4	,,	3·815	4·93 (1)	+ 1·115
Potassium nitrate N = 2·5 ,, 100,000 -	4	,,	3·815	5·17 (1)	+ 1·355
,, ,, N = 0·025 ,, 100,000 -	4	,,	3·815	4·77 (1)	+ 0·955
Ammonium chloride + sodium phosphate N = 2·5 P = 0·0025 - - - -	4	,,	3·815	5·11 (1)	+ 1·295
Ammonium chloride + sodium phosphate N = 0·025 P = 0·0025 - - - -	4	,,	3·815	5·51 (1)	+ 1·695
Potassium nitrate + sodium phosphate N = 0·025 P = 0·0025 - - - -	4	,,	3·815	4·93 (1)	+ 1·115
25 per cent. tap water - - - - - -	5	Sept. to Oct. (4 weeks).	3·96	4·98 (2)	+ 1·02
25 ,, ,, - - - - - -	5	,,	3·96	3·705 (2)	− 0·255
Ammonium chloride N = 0·025 per 100,000-	5	,,	3·96	4·755 (2)	+ 0·795
Potassium nitrate N = 0·025 per 100,000 -	5	,,	3·96	5·01 (2)	+ 1·05
Ammonium chloride + sodium phosphate + ferrous sulphate N. & Fe = 0·025. - P = 0·0025 per 100,000 - - - -	5	,,	3·96 4·59	5·08 (1) 4·96 (1)	+ 1·12 + 0·37

The number of determinations with corresponding solutions was, in these experiments, relatively small, and as a consequence, the absolute effect of each substance possibly uncertain. But some broad facts appear thus :—

Ammonium chloride.—Either alone or with other substances.

In all experiments an increase in nitrogen occurred. This was the greatest in the mixture of the salt (N=0·025 per 100,000) with sodium phosphate, namely 1·695.

The results of the experiments may be tabulated thus :—

Mixture.	Total number of determinations.	Average increase in per cent. N.
All experiments - -	8	1·049
Ammonium chloride alone -	4	0·955
Ammonium chloride alone N = 2·5 per 100,000 -	1	0·955
Ammonium chloride alone N = 0·025 per 100,000 -	3	0·955

Potassium nitrate.— Either alone or with other substances.

Here the matter is simpler as only one experiment was made in which some other substance was present (sodium phosphate). In this case the table is :—

Mixture.	Total number of determinations.	Average increase in per cent. N.
All experiments - -	5	1·112
Potassium nitrate only -	4	1·112
Potassium nitrate only N = 2·5 per 100,000 -	1	1·355
Potassium nitrate only N = 0·025 per 100,000	3	1·000
Potassium nitrate + sodium phosphate N = 0·025 per 100,000 - - - -	1	1·115

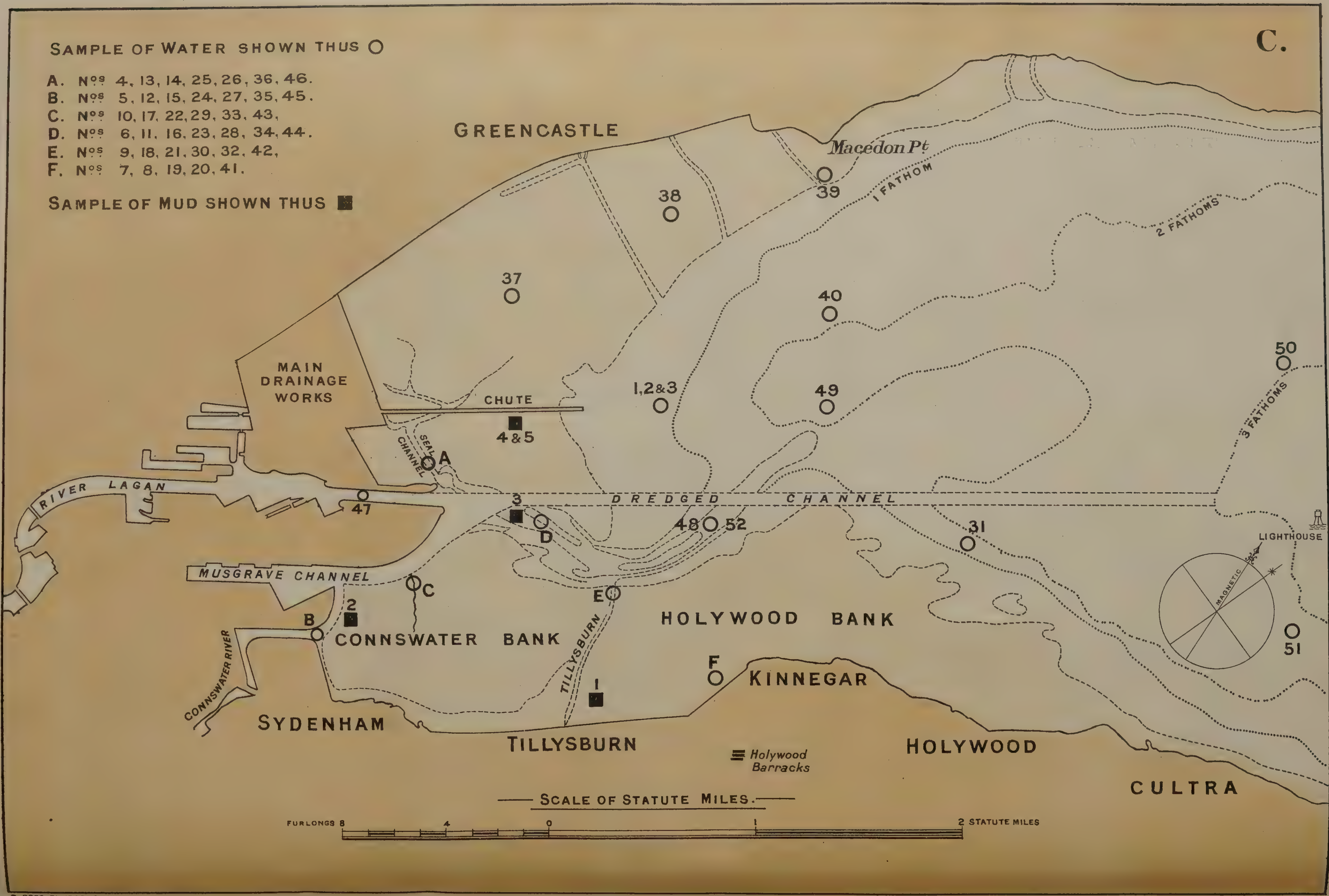
These results warrant in our opinion the conclusion that the nitrogen content of *Ulva* increases when the sea-weed is grown in sea-water containing ammonium salts or nitrates.

Tap water.—Only four determinations were made and we may as well tabulate them in full, as they illustrate the difficulties which may arise in an attempt to draw conclusions from a few experiments.

Mixture.	Total number of determinations.	Average change in per cent. N.
25 per cent. Tap water -	1	− 0·53
25 ,, ,, ,, ,, (shade)	1	+ 1·57
50 ,, ,, ,, ,, - -	1	− 0·26
50 ,, ,, ,, ,, (shade)	1	− 0·25

Here a solitary figure is for some reason which we have no clue to, out of all proportion different from the others.

It is unnecessary to say that no conclusions can be drawn from results of this kind.


C.
SAMPLE OF WATER SHOWN THUS ○
A. Nos 4, 13, 14, 25, 26, 36, 46.
B. Nos 5, 12, 15, 24, 27, 35, 45.
C. Nos 10, 17, 22, 29, 33, 43,
D. Nos 6, 11, 16, 23, 28, 34, 44.
E. Nos 9, 18, 21, 30, 32, 42,
F. Nos 7, 8, 19, 20, 41.
SAMPLE OF MUD SHOWN THUS ■
GREENCASTLE
Macedon Pt
1 FATHOM
2 FATHOMS
3 FATHOMS
38
39
37
40
50
MAIN DRAINAGE WORKS
CHUTE
1,2&3
49
4&5
SEAL CHANNEL
A
RIVER LAGAN
47
3
DREDGED CHANNEL
D
48
52
31
LIGHTHOUSE
MAGNETIC
MUSGRAVE CHANNEL
C
E
2
B
HOLYWOOD BANK
CONNSWATER BANK
51
CONNSWATER RIVER
TILLYSBURN
1
F
KINNEGAR
SYDENHAM
TILLYSBURN
Holywood Barracks
HOLYWOOD
CULTRA
SCALE OF STATUTE MILES.
FURLONGS 8
4
0
1
2 STATUTE MILES

4.—CHEMICAL ANALYSES OF THE WATERS OF BELFAST LOUGH.

TOPOGRAPHICAL PARTICULARS OF THE LOUGH.—Before describing the analytical work which has been done on the waters of the Lough, it may be useful to give a few topographical particulars regarding the Lough itself.

As will be seen from the map, the Lough is horn-shaped, the point of the horn corresponding with the mouth of the River Lagan and the broad extremity with the opening of the Lough into the Irish Channel. The southern or Co. Down side is situated on the inner bend of the curve and the northern or Co. Antrim side on the outer bend; the general trend of the curve from the mouth of the Lagan to the Irish Channel being in a north-easterly direction.

The distance from the mouth of the river to Blackhead (the northern extremity of the Lough) is about 13 miles as the crow flies, and from the same spot to Orlock Point (its southern extremity), much the same distance.

At the mouth of the river (or end of the "Twin Islands") the Lough is about 2½ miles wide. At Grey Point (situated about 7 miles from the mouth of the river)—somewhat under 3½ miles, after which it broadens out rapidly, the distance between Orlock Point and Blackhead being about 7 miles.

The upper reaches of the Lough are very shallow and extensive sand and mud banks are uncovered at low water, which reach almost from shore to shore near the city and continue for fully 4 miles down each side seawards, though gradually diminishing in width.

The most extensive of these banks and the most important in relation to the growth of *Ulva* are situated between the city and Macedon Point on the Co. Antrim side, and between the city and Cultra Pier on the Co. Down side.

As the area included within these limits is of special importance, the following distances may be given:—

From mouth of river to Macedon Point about 2½ miles.
From mouth of river to Cultra Pier about 3½ miles.
From Macedon Point to Cultra Pier about 3¼ miles.

While the areas of the banks uncovered at low tide (within the same limits) are:—

To Macedon Point, on the Co. Antrim side, about 1,300 acres.
To Cultra, on the Co. Down side, about 1,700 acres.

VOLUME OF SEWAGE ENTERING THE LOUGH AND COMPOSITION OF THAT CONTRIBUTED BY BELFAST.—Regarding the volume and composition of the Belfast sewage discharged into the Lough, the City Authorities have been so good as to give us permission to quote certain particulars from an unpublished pamphlet, containing the results of daily analyses (made by one of us during the year ending November, 1909, for the Corporation)—and other particulars supplied by the City Surveyor. The figure for the water supply has been obtained officially from the Belfast Water Commissioners.

Particulars Regarding the Sewage of Belfast, 1908–1909.

Population contributing - - - - -	364,020	
Water supply per head (for all purposes) -	38·11	gallons.
Average daily volume of sewage treated per unit of population - - -	54·47	,,
Average daily volume of sewage treated (Total) - - - - - -	19,830,000	,,
Rainfall for year - - - - - -	32·313	inches.

Average Composition of the Sewage.

Parts per 100,000.

Crude.

Screenings (dry). 0·460	Detritus (dry). 0·151

Screened.

Suspended solids (dry).	Nitrogen as :—		Chlorine.
	Free Ammonia.	Organic.	
32·153	2·001	1·946	54·53

Sedimented.

Suspended solids (dry).	Nitrogen as :—		Chlorine.
	Free Ammonia.	Organic.	
9·977	1·991	1·429	54·18

Regarding the sewage other than that discharged at the pumping station, the City Surveyor in his evidence before the Commission (February 16th, 1910) gave the following figures:—

Daily Average Flow (Dry Weather).

	Gallons.
Sydenham outlets - - - - - - -	75,000
Harbour estate and shipping - - - -	227,000
Co. Down population - - - - -	144,000
Co. Antrim population - - - - -	300,000
Total - - - - - - -	746,000

LAND WATER ENTERING THE LOUGH AT BELFAST.—The City Surveyor also gave a figure for the amount of fresh water entering the Lough through the River Lagan, based (1) on the area of the watershed (excluding 5¾ square miles—the built upon portion of the city area) which amounts to 270 square miles; (2) the assumption that two-fifths of the total rainfall reaches the Lough; and (3) that the average rainfall is 36 inches.

His estimate as thus calculated gives a daily flow of 154 million gallons.

Dilution of the Seawater in the Upper Reaches of the Lough.—The capacity of that portion of the Lough which is situated within a line drawn from Cultra Pier to Macedon Point, between average low and high water, may be taken as being roughly 8,000 million gallons. The seawater entering this portion during one (average) flood tide—say 6 hours—will be the above amount, less one-fourth of the combined daily flow of Lagan water and sewage, which is made up of:—

		Million Gallons.
Sewage from Pumping Station - - -	say	20
Sewage from Sydenham, Harbour Estate, Co.'s Down and Antrim - - - - -	,,	0·7
Flow of the Lagan - - - - - -	,,	154
Total - - - - - - -		174·7

And therefore the seawater entering during one tide:—

Million Gallons.

$$8{,}000 - \left(\frac{174{\cdot}7}{4} = 43{\cdot}7\right) \qquad \text{say} \quad 7{,}956$$

But the fresh water and sewage escaping during one complete tide (say 12 hours) will obviously be 43·7 × 2 = 87·4. Therefore we have the ratio:—

Seawater entering : Fresh water plus sewage escaping : :
7,956 : 87·4.

or in round numbers—
796 : 9.

giving a theoretical dilution of the seawater by rather more than 1·1 per cent. sewage and fresh water combined.

It will be seen from the analyses that the actual dilution as measured by salinity, is, in round numbers, from ten to twenty times as great, indicating in all probability a more or less permanent zone of dilution and pollution, which oscillates with each tide and remains fairly uniform in composition. The actual figures are no doubt affected by the extent of the rainfall.

PAST ANALYSES OF THE WATERS OF THE LOUGH.—One of us had made several series of analyses of these waters, during the years 1904–1905 for the Belfast Corporation, embracing in all about fifty samples.* Most of these were made on the Co. Antrim side and many in the direct flow of the sewage from the chute as traced by floats. If only those samples are taken into consideration which were collected within the boundary of a line drawn from Cultra Pier to Macedon Point, the average amount of ammoniacal nitrogen is about 0·04 parts per 100,000—corresponding with 2 per cent. of Belfast sewage.

In the year 1908 fresh analyses were undertaken for the Corporation—mainly on the Co. Down side between the city and Holywood. Fifteen analyses were thus made and the mean result as regards ammoniacal nitrogen is rather over half the previous figure, corresponding therefore with a pollution of about 1 per cent. of the Belfast sewage. The results as a whole were very uniform irrespective of the state of the tide.

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* The results of these are given in full in Appendix VI. to the Commission's fifth Report, pp. 234–261.

Analyses made during 1909–1910.—After the Commission had taken up the question of Belfast and Green Seaweeds generally, it was considered advisable to supplement the above analyses by others and in July, 1909, a preliminary series of examinations was made of samples collected in the neighbourhood of the chute at different depths. (Series A., Table XXXIV.)

Owing to pressure of other work, it was not possible to take up this matter again until the following January, during which month and the next, four series of samples were collected and examined. They were drawn about 2 feet below the surface, or less than this at low tide, as there was then in many of the localities barely enough water to float the boat from which as a rule the samples were collected. The samples of series 5 were collected in July, 1910.

BELFAST LOUGH.

SERIES A.—TABLE XXXIV.

Analyses of 24 Hours Average Samples of Lough Water Drawn Hourly from a Boat Anchored a Quarter of a Mile from the End of the Chute, between 1.0 p.m. July 22nd, and 12.0 noon, July 23rd, 1909. The Samples were Mixed in Equal Quantities.

(All results expressed as Parts per 100,000.)

	No. 1. 6 inches below the surface.	No. 2. Mid depth. Average, 3 feet 5 inches.	No. 3. 2 feet from bottom. Average, 7 feet.
Ammoniacal nitrogen - - - - - -	0·0176	0·0216	0·0280
Albuminoid nitrogen - - - - - -	0·0184	0·0208	0·0196
Chlorine (parts per 1,000) - - - -	18·50	18·60	18·84
Remarks - - - - - - - -	Rather turbid with much suspended matter: mostly very fine.	Similar to No. 1. Rather less flocculent solid.	Similar to Nos. 1 and 2, but with more suspended matter than No. 2.

BELFAST LOUGH.

SERIES 1.—TABLE XXXV.

Samples of Water Drawn on Wednesday, January 26th, 1910. High Water, Spring Tide, 11.22 a.m.

Air Temperature at 11.25 a.m. –0·5°C. Light Breeze from N.E. (Water Smooth).

(All results expressed as parts per 100,000; except when otherwise stated.)

	No. 4. Seal Channel	No. 5. Conns-water	No. 6. Old Channel	No. 7. Kinnegar	No. 8. Kinnegar	No. 9. Tillys-burn	No. 10. Gut in Slob	No. 11. Old Channel	No. 12. Conns-water	No. 13. Seal Channel
Time of Drawing:—	11.25 a.m.	11.45 a.m.	12.7 p.m.	12.27 p.m.	12.35 p.m.	12.45 p.m.	1.4 p.m.	1.7 p.m.	1.30 p.m.	1.38 p.m.
Temperature of sample when drawn.	2·5° C	3·2° C	2·6° C	2·6° C	2·3° C	3·2° C	2·1° C	2·2° C	3·3° C	3·0° C
Ammoniacal nitrogen	0·015	0·020	0·016	0·017	0·020	0·016	0·022	0·022	0·017	0·034
Albuminoid nitrogen	0·020	0·020	0·019	0·018	0·029	0·022	0·020	0·033	0·020	0·031
Dissolved oxygen taken up at 18° C in 5 days (by Winkler Method)	0·30	0·15	—	0·26	0·22	0·21	0·16	0·36	0·24	0·52
Chlorine (parts per 1,000).	17·00	17·08	15·46	15·92	15·68	15·32	15·28	15·92	15·88	16·24
Dissolved oxygen at 4 p.m. (c.c. per litre) Jan. 26 (by Winkler method).	—	—	—	6·68	—	6·80	—	—	—	—
Remarks.	Slack water. Turbid with much fine suspended solid.	Just ebbing. Fairly clear. Not much suspended solid.	A little fine suspended solid.	A little fine suspended solid. Inside barracks outfall.	As No. 7 No more suspended solid. Outside barracks outfall.	Some fine fibrous suspended solid. Flow of ebb tide parallel to shore.	A little suspended solid. Much ice floating by.	Not much pended solid. Flow slightly towards the Co. Down shore. Wind S.E. Fresher.	A little suspended solid. Strong ebb.	Much fine suspended solid. Strong ebb. down the channel.

BELFAST LOUGH.

SERIES 2.—TABLE XXXVI.

SAMPLES OF WATER DRAWN MONDAY, JANUARY 31ST, 1910. HIGH WATER, AVERAGE TIDE, 2.30 P.M. AIR TEMPERATURE AT 10.50 A.M. 5·2° C. WIND FRESH, SOUTH WEST. WATER CHOPPY.

(All results expressed as parts per 100,000 except when otherwise stated).

	No. 14. Seal Channel	No. 15. Connswater.	No. 16. Old Channel.	No. 17. Gut in Slob.	No. 18. Tillysburn.	No. 19. Kinnegar.	No. 20. Kinnegar	No. 21. Tillysburn.	No. 22. Gut in Slob.	No. 23. Old Channel.	No. 24. Connswater.	No. 25. Seal Channel.
Time of Drawing.	10.50 a.m.	11.15 a.m.	11.45 a.m.	12.0 noon.	12.7 p.m.	12.20 p.m.	3.20 p.m.	3.40 p.m.	3.45 p.m.	3.53 p.m.	4.5 p.m.	4.20 p.m.
Temperature of sample	3·6° C	4.0° C	3.4° C	3·5° C	3·6° C	3·7° C	3·7° C	3·6° C	3·6° C	3·7° C	3·6° C	3·5° C
Ammoniacal nitrogen	0·016	0·015	0·021	0·023	0·020	0·035	0·018	0·018	0·022	0·020	0·025	0·022
Albuminoid nitrogen	0·022	0·027	0·022	0·019	0·021	0·020	0·015	0·018	0·013	0·013	0·015	0·013
Dissolved oxygen taken up at 18° C in 5 days (Winkler method)	0·19	0·15	—	—	0·11	0·19	—	0·07	—	0·11	0·01	0·13
Chlorine (parts per 1,000)	17·68	18·40	17·32	17·60	17·44	16·76	17·44	17·96	17·88	18·32	17·92	17·88
Remarks	Moderate ebb. Much suspended solid.	Less suspended solid than No. 1.	Little suspended fine solid.	Very little suspended solid.	A little fine suspended solid.	A little fine suspended solid. Much broken *Ulva* floating by. Inside outfall, discharging. Wind freshening; choppy sea.	Less suspended solid than No. 6. Inside outfall.	A little fine suspended solid.	Very little fine suspended solid.	Some fine suspended solid.	Very little fine suspended solid.	Not so much suspended solid as No. 1.

BELFAST LOUGH.

SERIES 3.—TABLE XXXVII.

SAMPLES OF WATER DRAWN TUESDAY, FEBRUARY 8TH, 1910. HIGH WATER, SPRING TIDE, 9.38 A.M. AIR TEMPERATURE, 1.10 P.M., 5·5° C. WIND FRESH, NORTH NORTH WEST. WATER CHOPPY.

(All results expressed as parts per 100,000 except when otherwise stated.)

	No. 26. Seal Channel	No. 27. Connswater	No. 28. Old Channel	No. 29. Gut in Slob.	No. 30. Tillysburn	No. 31. Holywood	No. 32. Tillysburn.	No. 33. Gut in Slob.	No. 34. Old Channel.	No. 35. Connswater.	No. 36. Seal Channel.
Time of Drawing.	1.10 p.m.	1.25 p.m.	1.55 p.m.	2.20 p.m.	2.50 p.m.	3.30 p.m.	4.15 p.m.	4.25 p.m.	4.25 p.m.	4.44 p.m.	4.55 p.m.
Temperature of sample	5·3° C	5·1° C	5·2° C	5·4° C	5·3° C	5·6° C	5·6° C	5·3° C	5·4° C	5·2° C	5·3° C
Ammoniacal nitrogen	0·093	0·045	0·026	0·021	0·025	0·022	0·022	0·023	0·0 9	0·043	1·05
Albuminoid nitrogen	0·082	0·034	0·021	0·021	0·024	0·026	0·026	0·025	0·022	0·039	0·41
Dissolved oxygen taken up at 18° C in 5 days. (Winkler method)	0·16	0·16	0·18	0·05	0·13	0·11	0·17	0·13	0·14	0·21	Putrid; oxygen exhausted.
Chlorine (parts per 1,000)	16·08	13·52	14·32	15·92	15·28	16·48	13·52	13·52	11·52	11·60	8·60
Dissolved oxygen on February 9th (c. c. per litre). (Letts method)	2·97	6·15	6·18	6·66	*a* 7·70 *b* 7·47	5·82	6·42	6·18	6·06	6·12	0·00
Remarks.	Rather turbid. Considerable light brown suspended solid.	Some pieces of Ulva, and other suspended solid.	Fairly clear. Very little suspended solid.	Considerable suspended solid. Many small pieces of Ulva. Flow of ebb down the gut.	Considerable fine suspended solid. Some pieces of Ulva or other weed *a*. Winkler. *b*. Letts	Special sample taken while Dr. Dakin was using plankton net. Between Victoria Channel, No. 4. buoy and low water mark. Water smooth.	Squall come on. Water rough. Much broken weed.	Water rough. Sea breaking on banks. Considerable fine suspended solid.	Slightly turbid. Considerable fine suspended solid.	Water still ebbing. Should have turned an hour ago. Turbid. Considerable amount of suspended solid.	Very bad smell. Water filthy. Foul sample, appearance of sewage. Large amount of obvious sewage solids. Sewage smell (see page 103).

Sample No. 36. The City Surveyor has kindly allowed us to see the log kept at No. 2 pumping station, which shows that the E. pond was discharging sewage direct to Seal Channel from 4 to 6 p.m. on Feb. 8th.

NOTE BY DR. W. J. DAKIN ON SAMPLES OF SEDIMENT COLLECTED ON FEBRUARY 8TH, 1910.

(1) The solid matter in the water off Holywood which was collected by a silk net, consists almost entirely of animals and plants which were living at time of capture. Inorganic matter is present, but in very small quantity.

The following species were represented :—

Animals.

Balanus nauplii (young of rock barnacle)	Common.
Copepod nauplii	Very common.
Worm larvae (polychaeta)	Rather common.
Copepod (adult)	Common.
Tintinnidae	Fairly common.
Foraminifera	Rare.

Plants.

Diatoms	Fairly common.

The species present are :—

Biddulphia mobiliensis and two other species.
Asterionella. Chaetoceros.
Rhizosolenia. Thalassisthrix.

Plant Remains.

Not planktonic forms, impossible to say what the pieces are.

Corresponds to water sample No. 31, Series 3.

(2) The sediment from the last place visited (Seal Channel), which was present in such quantity that it could be obtained by decantation, consists almost entirely of inorganic matter and debris. It is, of course, impossible to compare the sediment obtained in this case with the former, because the catch taken with the net represents the organisms from a much larger volume of water. Taking, however, this into consideration, there appears to be extremely little animal or plant life (excepting bacteria and small forms) in the water from the last station visited. The debris cannot be recognised as belonging to any particular form. The only recognisable organic matter consisted of some pieces of coniferous wood (match remains ?) and a nematode worm.

Corresponds to water sample No. 36, Series 3.

BELFAST LOUGH.

SERIES 4.—TABLE XXXVIII.

SAMPLES OF WATER DRAWN MONDAY, FEBRUARY 28TH, 1910. HIGH WATER, SPRING TIDE, 1.11 P.M.
AIR TEMPERATURE AT 1.40 P.M. 9·5° C. WIND FRESH.

WATER SMOOTH ON THE ANTRIM SIDE OF LOUGH, BUT CHOPPY TO ROUGH ON THE DOWN SIDE.

(All results expressed as parts per 100,000 except when otherwise stated.)

	No. 37. Off Greencastle South	No. 38. Off Greencastle North	No. 39. Macedon Point.	No. 40. Between Macedon Point and Victoria Channel	No. 41. Kinnegar	No. 42. Tillysburn	No. 43. Gut in Slob.	No. 44. Old Channel	No. 45. Connswater	No. 46. Seal Channel
Time of Drawing.	1.40 p.m.	1.55 p.m.	2.15 p.m.	2.25 p.m.	2.55 p.m.	3.10 p.m.	3.25 p.m.	3.40 p.m.	5.0 p.m.	5.10 p.m.
Temperature of sample	5·4° C	5·2° C	5·4° C	5·3° C	5·2° C	5·4° C	5·2° C	5·1° C	5·2° C	5·2° C
Ammoniacal nitrogen	0·022	0·030	0·011	0·012	0·014	0·013	0·017	0·016	0·017	0·037
Albuminoid nitrogen	0·028	0·029	0·016	0·019	0·014	0·022	0·013	0·016	0·020	0·028
Dissolved oxygen taken up at 27° C in 5 days (*c*).	0·33	0·30	0·13	0·06	0·11	0·12	0·12	0·09	0·18	0·24
Chlorine (parts per 1,000).	15·88	16·60	16·88	17·32	16·60	16·00	16·80	16·32	16·84	15·68
Dissolved oxygen on March 1st. (c. c. per litre) (*b*).	6·59	5·91	6·72	6·71	*a* 6·97 *b* 7·08 *c* 6·67	*a* 7·01 *b* 7·12	6·74	6·60	6·32	5·95
Remarks.	Rather turbid.	Rather turbid.	Clear. Little suspended solid.	Considerable fine suspended solid. Water rough.	Bright looking. Moderate suspended solids.	Similar to No. 41.	Similar to Nos. 41 and 42.	Slightly turbid with more suspended matter than No. 43.	Considerable amount of fine suspended solid.	Turbid but not quite so much suspended solid as No. 45 Tide ebbing fairly fast.
Oxygen determination Methods :— (*a*) Gasometric. (*b*) Letts & Blake (volumetric). (*c*) Winkler (volumetric).										

BELFAST LOUGH.

SERIES 5.—TABLE XXXIX.

Samples of Water Drawn on Monday, July 18th, 1910. High Water, Neap Tide, 7.37 a.m.
Dry Weather for 10 Previous Days. Wind Fresh, North North-West. Water Rather Rough.

(All results expressed as parts per 100,000, except when otherwise stated.)

	No. 47. Between Twin Islands	No. 48. Outer End of Old Channel	No. 49. In Whitehouse Roads	No. 50. North-West of Light-house	No. 51. South of Lighthouse	No. 52. End of Old Channel (As No. 48)
Time of Drawing:	2.35 p.m.	2.55 p.m.	3.5 p.m.	3·45 p.m.	4.5 p.m.	4.30 p.m.
Temperature of sample when drawn.	18·0° C	18·2° C	17·7° C	16·7° C	16·8° C	17·7° C
Ammoniacal nitrogen	0·031	0·038	0·034	0·002	0·001	0·031
Albuminoid nitrogen	0·040	0·036	0·030	0·013	0·010	0·026
Dissolved oxygen taken up at 18° C in 6 days (Winkler method).	0·23	0·16	0·17	0·05	0·07	0·06
Chlorine (parts per 1,000)	17·04	17·76	17·92	18·90	18·76	18·00
Remarks.	Much suspended matter.	Considerable suspended matter.	Some suspended matter: less than No. 48.	Bright sample: a little suspended matter	Not quite so clear as No. 50.	Clearer than No. 48.

The figures for the fifty-two samples of Lough water which have been examined are given in Tables XXXV. to XXXIX. The first three series of samples were mostly drawn on the Co. Down side of the Lough and were intended to show the conditions at high water, half tide, and low water, respectively. Series 4 embraces a set of samples collected right round the upper part of the Lough from the corner between Greencastle and the pumping station reclamation bank, along the Antrim shore to Macedon Point, across to the Kinnegar and back to the Connswater and Seal Channel. (*See* Chart C.)

The results of the analyses of these samples show that under winter conditions, the pollution in the upper reaches of Belfast Lough, as measured by the figures for the ammoniacal nitrogen, is equivalent to about 1 per cent. of Belfast sewage, thus confirming in general the work previously done by one of us which has been alluded to above. This degree of pollution is remarkably uniform over the whole area in question and does not vary greatly at different states of the tide. The only place where excessive pollution occurred was the Seal Channel, and there only at the last of the ebb tide.

The samples drawn in the Old Channel were taken in order to ascertain whether there was a current of polluted water passing from the Seal Channel across the Victoria Channel towards the Co. Down shore at any state of the tide. The figures do not indicate that such a current exists, as the pollution in the Old Channel was not greater than that in the adjacent waters. It is quite possible that the sewage may pass across the Victoria Channel in this way, but it can only be in a state of dilution at least as great as that which is found along the Co. Down shore from Tillysburn to the Kinnegar. Next to the Seal Channel, the greatest pollution was found in the mouth of the Connswater river which is admittedly badly polluted. The volume of this river is however so small, that it is unlikely that its flow can increase the pollution existing in this corner of the Lough to any appreciable extent.

A point of considerable interest, in view of the results obtained in the experiments on the growth of *Ulva* in glass dishes and also for other reasons, is the degree of "brackishness" of the water over the sloblands and sandbanks. The average chlorine figures for Series 1, 2 and 3 are 15·98, 17·72 and 13·67, respectively, and the general mean for all three combined is 15·84. If the chlorine in pure seawater is taken as 19·50, this general mean corresponds with a dilution of the seawater with 19 per cent. fresh water.

The samples of Series No. 5 were drawn with the idea of ascertaining the extent of pollution in the old course of the Lagan, commonly known as the "Old Channel," and also the extent of pollution at two points in the neighbourhood of the lighthouse. The positions at which these samples were drawn are marked on Chart C.

It is noticeable that the figures for the ammonia and chlorine in the samples collected in the upper reaches of the Lough are higher than those found in the winter in Series 1 to 4. This was due, no doubt, to the dryer weather prevalent in July when the samples of Series 5 were collected.

The uniformity observed in the ammoniacal nitrogen of the winter samples is also evident in Series 5, practically the same figure being found in Samples 47, 48 and 49.

The absorption of dissolved oxygen bears little relation to the ammoniacal nitrogen, but would appear to depend largely on the amount of suspended matter present. Sample No. 52 is interesting in this respect, as it has the same figure for ammoniacal nitrogen as No. 47, but takes up only one quarter the amount of dissolved oxygen. It also illustrates the effect of the flood tide very clearly by comparison with No. 48. Both of the samples collected near the lighthouse (Nos. 50 and 51) were very pure, and the chlorine figures indicate that they consisted mainly of sea-water.

Speaking generally, this series of results confirms those obtained in the preceding Series (1 to 4) and of the older analyses.

Conclusions.

The results of these analyses show that the water over the Co. Down foreshore is polluted to the extent of from 1 to 2 per cent. of Belfast sewage measured by the ammoniacal nitrogen figures. This degree of pollution exists very uniformly all over the upper reaches of the Lough inside a line joining Macedon Point to the Kinnegar.

The only places where greater pollution was found were in the mouth of the Connswater river and in the Seal Channel. In the latter the pollution on one occasion rose as high as 50 per cent. sewage, but this was due to direct discharge from the embankment valves, while reconstruction works were in progress. When the new tanks are completed and all the sewage discharged through a properly constructed chute, there should be no greater pollution here than in the upper reaches of the Lough generally.

With the two exceptions mentioned in the tables, all the samples were well oxygenated, and from their general chemical character, were not likely to cause any direct nuisance.

It is interesting to inquire whether a uniform pollution of the waters of the upper reaches of the Lough to the extent of from 1 to 2 per cent. of sewage (as found by analysis), coupled with diminution of salinity corresponding with an admixture of 10 to 20 per cent. of fresh water, are in accordance with the quantities of sewage and fresh water which the Lough actually receives.

We have seen that the combined volumes of these latter, according to the available data, amount on an average to about 174·7 million gallons daily, of which

20·7 million gallons are sewage, and also that the theoretical dilution of the seawater entering the upper reaches of the Lough is largely exceeded (Cf. p. 99).

With a brackishness of 10 per cent. (*i.e.*, assuming an admixture of 10 vols. of polluted fresh water with 90 vols. of pure seawater), the volume of sewage theoretically present in 100 volumes of Lough water should be 1·2 vols., thus :—

$$174{\cdot}7 : 20{\cdot}7 :: 10 = 1{\cdot}2$$

The calculation is, of course, of a rough and ready kind and does not take into consideration variations in the relative volumes of river water and sewage induced by heavy rainfalls, etc., but, as is apparent, its results agree in rather a surprising way with those of the actual analyses. These results fortify us in the idea of an oscillating zone of pollution in the upper reaches of the Lough, which on the ebb tide loses at its seaward extremity a certain proportion of the polluted mixture, or in other words a certain fraction of the whole passes out to sea, while this becomes replaced, partly by seawater entering the zone on the flood tide and partly by sewage and fresh water entering the other extremity of the zone, both eventually intermingling.

The late engineer to the Harbour Board (Mr. Giles) was of the opinion that the seawater entering the Lough formed two bifurcating streams somewhere near the lighthouse, which mingling with the polluted water, flowed along the two shores, thus giving rise to a more or less uniform mixture. A copy of the chart which he constructed in support of these views is before us as we write.

We do not know if this theory is correct, but if it is, it would certainly explain, to a large extent, the actual condition of affairs as indicated by the chemical analyses of the Lough waters.

5.—CHEMICAL ANALYSES OF SEAWATER FROM SOME LOCALITIES NEAR BELFAST.

Regarding the analyses which are next given, the following observations may be made :—

Strangford Lough.—This Lough is, roughly speaking, of about the same area as Belfast Lough and, like the latter, in its upper reaches, exposes at low water extensive sand and mud banks. The predominant marine vegetation on these is, however, *Zostera marina* or "Sea Grass," and not *Ulva* (as in the case of Belfast Lough).

Strangford Lough receives very little sewage pollution as there are no towns of any large size on its shores. But on the other hand there is much natural pollution from rotting seaweeds, especially in the numerous bays, some of which like Reagh Bay, are almost landlocked. It was from a corner of this bay that Sample No. 2 was collected, where there was much rotting seaweed such as *Zostera*, "*May Fog*," etc., which was very foul and caused a decided nuisance. It will be seen that this sample of water was rich in ammoniacal nitrogen and corresponded in that factor with about one half per cent. of Belfast sewage.

Strangford is remarkable for the number of its islands (of which it is said there are over 360), and Sample No. 1 was collected from one of these, namely, Island Mahee, situated at the entrance to Reagh Bay.

This spot was interesting as there was a fairly luxuriant growth of *Ulva* on some rocks which had been recently turned over to form a boat quay. It will be seen that this sample of water contained about three times the maximum amount of ammoniacal nitrogen which we have normally found in pure seawater, the maximum of albuminoid nitrogen and a medium amount of nitrate in relation to pure seawater. (*See also* p. 110 and Mr. Cotton's Botanical Report, p. 126).

Giant's Causeway.—For the conditions regarding Sample No. 3, *see* Mr. Cotton's Report, p. 127.

TABLE XL.

ANALYSES OF SAMPLES OF WATER DRAWN AT STRANGFORD LOUGH AND GIANT'S CAUSEWAY.

(All results expressed as parts per 100,000.)

	No. 1. From pier at Island Mahee, Strangford Lough.	No. 2. From pools in the slob by side of road to Island Mahee.*	No. 3. Giant's Causeway.
	May 3rd, 1910.	May 3rd, 1910.	May 8th, 1910.
Ammoniacal nitrogen - - - - - -	0·003	0·011	0·005
Albuminoid nitrogen - - - - - -	0·011	0·056	0·043
Nitric nitrogen - - - - - - -	0·006	—	—
Remarks - - - - - - -	Clear bright sample with a little fine suspended matter.	Turbid, brownish, much suspended matter, chiefly decayed weed. Seaweed smell.	Very small sample. Results unreliable.

* This is where the nuisance arises from decay of *Enteromorpha prolifera*.

6.—THE ANALYTICAL CHARACTERISTICS OF PURE SEAWATER.

It is obviously of importance in relation to the *Ulva* problem to know the characteristics of pure seawater, as shown by chemical analysis, and, as regards Belfast in particular, those of the pure seawater entering the Lough, and the following investigations have been made with that object.

It is scarcely necessary to say that all the constituents of the tissues of *Ulva* are present in pure seawater, some of them, however, in only minute quantities. It is, indeed, well known that seaweeds have the power of accumulating relatively large quantities of certain elements in their tissues, even when these are present in such traces in seawater that they cannot be detected even in considerable volumes of it by the ordinary chemical tests. Iodine is a good example of this, for while it is extremely difficult to detect it in seawater, it forms a sufficiently large proportion of the ash of certain seaweeds to enable its extraction, even by methods which may now be considered as more or less primitive, to be commercially profitable. Iodine has recently been detected in *Ulva* in small amount while phosphorus is present to the extent of over 0·1 per cent., yet while that element is no doubt present in pure seawater, we have been unable to detect it in two litres of seawater from the Irish Channel.* The analyses of *Ulva* given on pp. 93–97 of this Report show that nitrogen can be present in very varied proportions, depending apparently on the degree of pollution of the water in which the seaweed grows. We have examined eighteen samples of water (Series A.) collected about 3 miles outside Blackhead (which, as elsewhere stated, forms the northern extremity of Belfast Lough) and four samples drawn much farther out in the Irish Channel (Series B.).

In all these samples, determinations were made of the nitrogen as :—

(1) Free ammonia.
(2) Albuminoid ammonia.
(3) Nitrates.

The following results were obtained :—

TABLE XLI.

ANALYSIS OF PURE SEA WATER.

Series A.

Samples collected about 3 miles outside Blackhead, the northern extremity of Belfast Lough.

(All results expressed as parts per 100,000.)

Sample.	Nitrogen as Free Ammonia.	Nitrogen as Albuminoid Ammonia.	Nitrogen as Nitrate.
1	0·0000	0·007	0·005
2	0·0002	0·007	0·006
3	0·0014	0·006	0·007
4	0·0003	0·010	0·006
5	0·0000	0·009	0·004
6	0·0005	0·007	0·003
7	0·0004	0·008	0·004
8	0·0006	0·011	0·003
9	0·0002	0·008	0·005
10	0·0009	0·008	0·004
11	0·0000	0·008	0·009
12	0·0002	0·008	0·003
13	0·0000	0·008	0·004
14	0·0000	0·004	0·003
15	0·0000	0·005	0·003
16	0·0000	0·008	—
17	0·0008	0·005	0·002
18	0·0004	0·005	0·006
Means - -	0·00033	0·0073	0·0045
Maxima - -	0·0014	0·011	0·009
Minima - -	0·0000	0·004	0·002

Series B.

Samples collected in mid-channel from the Belfast—Heysham steamers.

(All results expressed as parts per 100,000.)

1	0·0000	0·007	0·009
2	0·0000	0·010	0·003
3	0·0038	0·006	—
4	0·0015	0·008	—

The following remarks may be made on these results :—

Free Ammonia.—It will be seen that the amount of this factor (in Series A. at least), ranged from zero to 0·0014, the mean being 0·00033. We have satisfied ourselves that free ammonia is apt to increase on keeping samples of pure seawater, a fact which has given considerable trouble in certain of our experiments. A specific example will illustrate this increase :—

A sample of the A. series contained 0·0004 parts per 100,000 when drawn, but after keeping it for a month in a stoppered stone jar in the laboratory, the amount rose to 0·001.

We have some grounds for believing that this increase in ammoniacal nitrogen is due to the decay of the minute organisms which constitute the *plankton* found both in fresh and seawater. Thus in the case referred to, on emptying the jar containing the sample, much suspended matter was found.

On the other hand, a sample of seawater drawn from the same locality about a month later and kept for five weeks in the laboratory, showed then 0·004, while a sample passed through a Pasteur-Chamberland filter and kept for the same time, showed precisely the same amount. In this case any notable quantities of *plankton* were probably absent, as the original water sample contained very little suspended matter. As this question is of some importance and the evidence recorded above is not sufficient for definite conclusions to be drawn, further experiments have been made which we shall refer to later.

Albuminoid Ammonia.—It will be seen that on an average the amount of this factor in Series A. was about twenty-two times as great as that of the free ammonia (mean of albuminoid nitrogen 0·0073, maximum 0·011, minimum 0·004), and the question arises as to how much of this is due to living organisms, and how much to dissolved nitrogenous compounds. Experiments on this matter will be described in this section under *Plankton.*

Oxidised Nitrogen.—We have satisfied ourselves that nitrates *were* present in the majority of the samples of pure seawater examined by us. In certain of these, oxidised nitrogen was tested for qualitatively, and its presence was at once indicated either by the blue tint which was produced when some of the water was added to 2 per cent. solution of diphenylamine in strong sulphuric acid, or by the brucine test.

Regarding this latter, 25 c. c. of the seawater placed in a porcelain dish along with a few drops of brucine sulphate solution and 25 c. c. of strong sulphuric acid added, showed the transient pink colour quite distinctly and a well marked yellow tint afterwards, which was permanent for 24 hours, while in a comparison experiment with the same quantities of distilled water (in place of seawater) and of reagents, the mixture remained colourless.

The oxidised nitrogen was determined by the zinc-copper couple, in lack of a better method, and while it is possible that the determinations were affected by the effect which Purvis and Courtland have described in relation to the breaking down of the organic matter by the couple, with evolution of ammonia,* the error if introduced at all, was probably minute and sufficiently constant to render the results strictly comparable with each other.†

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* The water was evaporated to dryness with excess of nitric acid, the residue dissolved in water and again evaporated to dryness with excess of ammonium molybdate and nitric acid. No trace of a yellow colour or precipitate could then be seen.

* Phil. Soc. Proc. Cambridge., Vol. XIV., Part V.

† The accuracy of the zinc-copper couple method for determining nitrates in seawater was tested as described on p. 120.

With regard to nitrous nitrogen, the meta-phenylene diamine test used in its estimation is not nearly so delicate as the zinc-copper couple method used for estimating oxidised nitrogen, whether in the form of nitrates or nitrites, nor as delicate as the two qualitative tests mentioned above. The smallest amount of nitrous nitrogen that can be estimated (without concentration of the sample) by the meta-phenylene diamine method is 0·01 part per 100,000, while 0·005 can be detected as a "trace." If nitrous nitrogen is present in less than this amount, it would be reckoned as nitric nitrogen by the zinc-copper couple method, by which as little as 0·002 parts per 100,000 may be determined, though the accuracy of the estimation may be affected by the Purvis-Courtland effect, if organic nitrogen is also present.

In searching for a more delicate method for the estimation of nitrites, we found that 0·001 part of nitrous nitrogen per 100,000 added to pure seawater, either in the form of potassium nitrite or produced by the aerobic fermentation of sewage and seawater in the laboratory, can be readily detected when 50 c. c. of the water are tested with potassium iodide, starch and dilute sulphuric acid. In pure seawater (A. series), these reagents gave no trace of colour. We are of the opinion therefore that the small quantity of oxidised nitrogen in pure seawater is present in the form of nitric nitrogen.

Plankton.—The amount of this in pure seawater, we are informed by zoologists varies considerably from time to time, and certainly in such samples as we have examined the amount of suspended matter varied greatly.

It occurred to us that a chemical estimate of the amount of *plankton* might be arrived at by analyses of samples before and after filtration through a Pasteur-Chamberland (or Berkefeldt) filter. The amount of *plankton* would then at least be indicated by the loss in albuminoid nitrogen in the filtered sample, and quite possibly the ammoniacal nitrogen might also be affected, as it is by no means inconceivable that the juices of the minute organisms of which this material consists, may contain ammoniacal compounds.

And further, if *plankton* on decaying gives rise to ammonia, on keeping the unfiltered samples the ammoniacal nitrogen should rise (as we had indeed found to be the case), while that of the filtered samples should not.

The following experiments were made, in which rather over a litre of the seawater in each case, was passed through a Pasteur-Chamberland filter (previously heated and washed by passing ammonia-free water through it until all traces of ammonia were removed). Samples of the unfiltered and filtered seawater were then analysed, while duplicates were kept in stoppered bottles for a week and then again analysed. The results were as follows:—

TABLE XLII.—SAMPLES OF SEAWATER FROM THE IRISH CHANNEL.

A.—As Collected; B.—After Filtration Through a Pasteur-Chamberland Filter; And C.—After Keeping Both the Filtered and Unfiltered Samples for a Week.

	Unfiltered.						Filtered.					
	When Collected.			After a Week.			When Collected.			After a Week.		
Nitrogen as:—	1*	2*	3†	1*	2*	3†	1*	2*	3†	1*	2*	3†
Free ammonia -	0·0135	0·00175	0·0038	0·012	0·00575	0·009	0·014	0·0015	0·003	0·014	0·0015	0·003
Albuminoid ammonia - -	0·012	0·009	0·006	0·009	0·008	0·003	0·006	0·006	0·004	0·006	0·006	0·004
Nitrate - -	0·002	0·000	—	0·005	0·0075	—	0·002	0·000	—	0·002	0·0025	—

* From Blackhead. † From mid-channel.

It will be seen that in samples Nos. 2 and 3, the free ammonia showed a distinct increase after keeping the original samples for a week, while No. 1 (from Blackhead) contained a very considerable amount of free ammonia when first analysed, and this remained practically the same after 7 days. As was expected the candle-filtered samples showed no change in either free or albuminoid ammonia on keeping.

7.—ANALYSES OF SOME OTHER SAMPLES OF SEA WATER.

It may be useful to give in this part of our report the results of the analyses of some samples of seawater collected by the Commission in September 1910, during an investigation which they made in relation to the growth of *Ulva* in certain localities in the south of England, because (1) some of the samples of *Ulva* collected by them were examined by us in Belfast; (2) we subsequently visited some of these localities along with Mr. Cotton and also collected samples of seawater and *Ulva* from one of them, viz., Studland Bay; and (3) because the *Ulva* we then collected has been the subject of certain experiments which we describe on p. 118. It will be seen that several of the samples collected by the Commission correspond in composition with seawater from the Irish Channel and notably one from Swanage (first sample), and those from Studland Bay.

TABLE XLIII.

SAMPLES OF SEAWATER COLLECTED BY THE COMMISSION DURING THEIR TOUR ON THE SOUTH COAST OF ENGLAND IN SEPTEMBER, 1910.

(The Samples were Analysed by Dr. McGowan.)

(All quantities expressed as Parts per 100,000.)

	Swanage.			Poole Harbour.	
	50 yards from Shore off Grosvenor Hotel and near the Jetty.	Among Seaweed just off Grosvenor Hotel about Low Water.	Off Rock near Centre of Durlston Bay. 300 to 400 yards South of Outfall.	Drawn off Round Mud in Mid-Channel from Poole to Mouth of Harbour.	At End of Salter's Pier.
Ammoniacal Nitrogen	0·001	0·002	0·002	0·001	0·0057
Albuminoid Nitrogen	0·006	0·009	0·010	0·012	0·023
Nitric Nitrogen	0·004	0·000	0·006	0·000	0·000
Chlorine	2024	2032	2038	1910	1798
Oxygen when analysed	0·81	1·33	1·30	1·15	0·90
Oxygen taken up in 5 days	0·02	0·12	0·09	0·04	0·17
Remarks	Clear and bright.	Clear and bright.	Clear and bright.	Clear, trace of suspended solids. Faint earthy smell.	Clear, trace of solids. Faint earthy smell.

	Studland Bay.			Weymouth.		
	30 yards from Cliff and High Watermark. About Centre of Cliffs.	200 yards from Shore Just Outside Bay where *Ulva* was Growing Abundantly.	300 yards from Shore in Front of Tea Shanty.	Backwater 100 yards off Centre of Promenade.	Backwater-Middle, between Railway and Swanning.	Backwater. Under Railway Bridge.
Ammoniacal Nitrogen	0·0014	0·0011	0·0012	0·0026	0·0015	0·0014
Albuminoid Nitrogen	0·014	0·0071	0·0084	0·026	0·038	0·017
Nitric Nitrogen	0·010	0·004	0·008	0·002	0·002	0·002
Chlorine	2000	2012	2020	1870	1764	1880
Oxygen when analysed	1·03	0·97	0·99	1·02	1·18	1·11
Oxygen taken up in 5 days	0·09	0·09	0·25	0·33	0·42	0·12
Remarks	Rather turbid with fine suspended matter. Faint sea smell.	Clear and bright. Merest trace of solids. No smell.	Clear and bright. Merest trace of solids. Faint sea smell.	Faintly opalescent with fine suspended solids. Faint fishy smell.	Somewhat opalescent with fine suspended solids. Strong sweet smell of decayed seaweed.	Some fine suspended solids. No smell.

	Southampton.		
	Hamble River. 300 Yards up. Nearly Low Water.	Quarter of a Mile Below Netley Pier and Outfall.	In Main Stream Between Milbrook Station and Cracknore Hard.
Ammoniacal Nitrogen	0·0011	0·0016	0·0066 (0·0066 p.f.)*
Albuminoid Nitrogen	0·031	0·040	0·23 (0·13 p.f.)*
Nitric Nitrogen	0·002	0·006	0·00 (0·00 p.f.)*
Chlorine	1940	1950	1624
Oxygen when analysed	0·90	0·71	0·68
Oxygen taken up in 5 days	0·45	0·35	0·68 (all)
Remarks	Clear, fair amount of fine grey suspended solids. No smell.	Clear, small amount of fine pale suspended solids. Very faint earthy smell.	Rather turbid and red with small animalculæ. Strong wormy smell. *N.B.*—Sample had a most objectionable smell on keeping.

* p.f. signifies paper-filtered.

TABLE XLIV.

SAMPLES OF STUDLAND BAY WATER COLLECTED BY MR. COTTON AND OURSELVES IN NOVEMBER, 1910.

(The samples were analysed by Dr. McGowan.)

(All quantities expressed as parts per 100,000.)

	Drawn at Dead Low Water in Pool on Sands below Tea Shanty, just N. of a Small Fresh Water Stream.	Studland Cliff. From a Rock Pool where *Ulva* was growing.	Studland Cliff. Another Pool near the Pilot's Path. Fed by Drainings from Rotting Seaweeds.
Ammoniacal nitrogen - - -	0·001	0·002	0·002
Albuminoid nitrogen - - -	0·015	0·006	0·035
Nitric nitrogen - - - -	0·052	0·180	0·010
Chlorine - - - - - -	1592	1250	1856
Solids, by centrifuge - - -	8·4	3·2	19·0
Oxygen, when analysed - -	0·92	0·88	0·69
Oxygen taken up in 5 days - -	0·15	0·06	0·38
Remarks - - - - - -	Rather opalescent. Considerable suspended matter No smell.	Bright. Clear. Trace of suspended matter. No smell.	Brown and turbid. Lot of fine brownish suspended matter. Strong fishy smell.

8.—ANALYSES OF MUDS DRAWN FROM THE SLOB LANDS AND FOR COMPARISON, AN ANALYSIS OF A SAMPLE OF SEWAGE SLUDGE TAKEN FROM THE SEDIMENTATION TANK AT No. 2 PUMPING STATION.

As it had been frequently asserted that the nuisance arising from the moblands was due to sewage matters deposited on them or held there entangled in the rotting seaweed, samples of the black mud were drawn at various places, some on the Co. Down foreshore and some in the neighbourhood of the chute (See Chart C.). It was considered that by analysing these and comparing the results with those obtained from a sample of sewage solids, evidence might be obtained as to the main constituent of the mud on the Co. Down moblands: whether, that is, it was as suspected, decayed *Ulva* or was sewage deposit.

The figures obtained from these samples are given in the following tables.

Although the results are not so distinctive as might be wished, the chief point brought out by the figures is the high sulphur content of the muds on the Holywood and Connswater banks compared with the other samples of mud and with sewage sludge. These banks are the chief nursery of the *Ulva*. Fresh *Ulva* taken from the moblands contains over 4 per cent. of sulphur (See p. 93. of this Report), but sewage sludge contains only 0·46 per cent. This indicates that the mud on the Holywood and Connswater banks is largely composed of decayed *Ulva* and not, as has been alleged, of sewage solids.

TABLE XLV.

BELFAST LOUGH.

MUDS.

Sample.		Mud which passed through a Sieve, 1 mm. mesh.		Residue on Sieve.	
		Percentage Calculated on Original Wet Sample.	Percentage Calculated on Sample Dried at 100°C.	Percentage Calculated on Original Sample.	Percentage Calculated on Sample Dried at 100°C.
No. 1 -	Sample of decomposed and decomposing *Ulva latissima* from Holywood Bank. The *Ulva* was probably deposited on the Bank during July and August, 1909. Taken September 29th, 1909; kept in ice. Examined October 11th, 1909. Black thick mass of fragments of dark green leaves, with some fine mud and grit (sand); alkaline; much sulphuretted hyrdogen.	18·45	79·9	4·63	20·1. Undecomposed weed 13·4 per cent.; Bivalve 6·7 per cent.
No. 2 -	Mud on bank off the mouth of the Connswater. Supposed to be sewage sludge, but probably *Ulva* mud. Taken September 29th, 1909; kept in ice. *Note.*—The bank off the mouth of the Connswater is the main nursery of the *Ulva*. Examined October 13th, 1909. Black, very thick mud; odour of spent sea-weed; slight smell of sulphuretted hydrogen; alkaline.	34·7	99·1	0·30	0·9. Chiefly undecomposed weed.
No. 3 -	Mud dredged from the side of Victoria Channel, opposite No. 10 Buoy, close to the Red and White Buoy, near the entrance to Musgrave Channel. Taken 12.30 noon, September 30th, 1909. In ice October 4th. Examined October 20th, 1909.	34·56	99·6	0·11	0·4. Very small residue, partly *Ulva*, green and brown.
No. 4 -	Surface mud (about 1 inch deep) on slob-land close to the side of chute, three-quarters of a mile from the inlet end. Taken 6.15 p.m., October 1st, 1909. In ice October 4th, 1909. Examined October 15th, 1909. Black, fairly fluid sludge (*i.e.*, compared with Nos. 1 and 2); strong septic smell; much sulphuretted hydrogen; some white deposit on surface (probably sulphur).	39·81	91·0	3·94	9·0. Chiefly shellfish, conchiform, 2 to 3 mm. long. A few rather large fragments of *Ulva*.
No. 5 -	(Sewage sludge)? Mud 6 inches below surface on slob-land, close to side of chute and three-quarters of a mile from the inlet end. Taken 6.17 p.m., October 1st, 1909. In ice October 4th. Examined October 19th, 1909. Compared with 4 apparently a good deal of sand in this sample. Quite black, very thick, smelling strongly of sulphuretted hydrogen. Sampled in basin because of thickness.	46·14	86·4	7·28	13·6. Some short straw-like pieces; oat husks, fragments of wood, coal, a few small shellfish (2 to 3 mm. long). Some weedy debris. Apparently no *Ulva*.

Note.—The determinations and notes in this table were made in Dr. McGowan's laboratory at Ealing.

TABLE XLVI.

MUDS AND SLUDGE.

Parts per cent. Samples Dried at 100° C.	Holywood Bank. No. 1.	Connswater Bank. No. 2.	Victoria Channel. No. 3.	Side of Chute 1 in. deep. No. 4.	Side of Chute 6 in. deep. No. 5.	Sludge from sedimentation tank at No. 2 Pumping Station. No. 6.
Matter volatile on ignition - - - - -	9·85	10·73	7·72	5·40	11·15	60·25
Kjeldahl nitrogen - - - - - - -	0·51	0·38	0·40	0·35	0·42	2·94
Silica and grit - - - - - - -	77·64	67·54	72·18	81·44	71·66	26·49
Ferric oxide - - - - - - - -	2·90	5·17	4·34	2·96	5·80	1·81
Sulphur - - - - - - - -	0·98	1·39	0·47	0·44	0·44	0·46
Equivalent to sulphuric anhydride ($S O_3$) -	2·45	3·47	1·17	1·10	1·09	1·15
Phosphorus - - - - - - - -	0·09	0·17	0·11	0·08	0·09	0·22
Equivalent to phosphoric anhydride ($P_2 O_5$) -	0·20	0·32	0·26	0·19	0·20	0·51

SAMPLES OF MUD FROM STRANGFORD LOUGH.

These samples may be compared with those taken in Belfast Lough, as being from a locality where there is no *sewage* pollution.

Sample No. 7 was taken from the shore near the boat pier at Island Mahee. *Ulva* was growing on the rocks near by. The water was clear.

Sample No. 8 was taken from a very shallow backwater hardly covered at high tide, where a considerable nuisance is caused in summer from rotting weed—in this case not *Ulva* but *Enteromorpha prolifera*.

	Sample No. 7.	Sample No. 8.
	Parts per cent.	
Kjeldahl nitrogen -	0·39	0·29
Matter volatile on ignition - - - -	10·30	9·34

These figures are very similar to the samples Nos. 1, 2, and 3 from Belfast Lough. They are slightly less nitrogenous, but the organic matter is about the same.

9.—THE CHEMICAL CHANGES OCCURRING IN SEAWATER POLLUTED WITH SEWAGE, COMPARED WITH THOSE WHICH TAKE PLACE IN CORRESPONDINGLY POLLUTED FRESH WATER.

It may be mentioned that some years ago, one of us in collaboration with others published the results of a series of experiments on the chemical changes occurring in mixtures of seawater with 1 per cent. sewage (*a*) in closed and (*b*) in open vessels, at a fixed temperature,[*] but that while certain of the results obtained were sharply defined, such as in (*a*) the relatively rapid loss of dissolved oxygen and gain in carbonic anhydride, others were less so: and that whereas there appeared to be distinct evidence of nitrification in both cases, the process seemed to take place much less rapidly than in similarly polluted fresh water, but no direct comparative experiments were made on the latter point.

It may be mentioned that the 1 per cent. mixture was decided upon as representing a proportion of sewage not likely to be exceeded in most cases of seaside pollution, at a reasonable distance from the outfall.

For several reasons which we need not specify, it appeared desirable to continue and amplify this work in connection with the investigations which form the subject of this report.

Three series of experiments have been made with 1 per cent. mixtures of (Belfast) sewage and both fresh and seawater, under the following conditions:—

1. In completely filled and stoppered bottles at 65° F. for five days.
2. In completely filled and stoppered bottles at 80° F.
3. In completely filled and stoppered bottles at temperatures of 60°, 70° and 80° F.

In all, nearly 300 separate determinations were made, so that the work was laborious.

The results are given in the three tables following:—

TABLE XLVII.

PRELIMINARY SERIES—1.

ONE PER CENT. BELFAST SEWAGE[*] MIXED WITH (*a*) TAP WATER; AND (*b*) SEAWATER. INCUBATED IN STOPPERED AND COMPLETELY FILLED BOTTLES AT 65° F. (18.3° C.) FOR FIVE DAYS.

(Dissolved gases expressed as cc. per litre at N.T.P. Other quantities as parts per 100,000.)

Tap Water Mixture.	
Ammoniacal nitrogen - - - -	0·017
Albuminoid nitrogen - - - -	0·014
Dissolved Oxygen (Winkler) at start -	6·2†
Dissolved Oxygen (Winkler) after 5 days	4·7
Seawater Mixture.	
Ammoniacal nitrogen - - - -	0·030
Albuminoid nitrogen - - - -	0·013
Dissolved Oxygen (Winkler) at start -	5·0‡
Dissolved Oxygen (Winkler) after 5 days	3·6

* The sewage was screened and settled (but not paper filtered) in this and the three subsequent series of experiments.

† Distilled water when saturated with air at 18° C. and 760 m.m. contains, according to Dittmar 6·76 c.c. per litre.

‡ The figure for sea-water under the above conditions is 5·51 c.c. per litre.

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[*] Letts, Blake, Caldwell and Hawthorne, *Proc. Roy. Soc.* Dublin, Vol. IX. (N.S.), Part III., No. 24.

TABLE XLVIII.—SERIES. 2.

1 PER CENT. BELFAST SEWAGE MIXED WITH: (*a*) TAP WATER; AND (*b*) SEAWATER. THE MIXTURES SATURATED WITH AIR AT 80° F. AND INCUBATED IN FULL AND STOPPERED BOTTLES.

(Dissolved gases expressed as c.c. per litre at N.T.P. Other quantities as Parts per 100,000.)

Tap Water Mixture.		When Mixed.	After 24 hours.	After 4 days.	After 7 days.	After 35 days.	Tap Water alone.	Tap Water alone after 35 days.
Ammoniacal Nitrogen -		0·018	0·021	0·026	0·023	0·006	0·0002	0·0016
Albuminoid Nitrogen - -		0·019	0·021	0·024	0·022	0·014	0·0106	0·018
Nitric Nitrogen - - -		—	—	—	—	0·032	—	0·018
Carbonic Anhydride	Gasometric	32·203	31·780	33·751	33·468	—	—	34·637
Nitrogen - -		12·133	12·050	12·042	11·924	—	--	12·504
Oxygen - -		6·036	6·080	4·929	4·832	—	—	2·608
Oxygen (Winkler)—Volumetric - - - -		5·81	5·44	4·87	4·55	1·19	5·77	2·43
Sea Water Mixture.							Sea Water alone.	Sea Water alone after 35 days
Ammoniacal Nitrogen -		0·030	0·023	0·022	0·023	0·026	0·004	0·009
Albuminoid Nitrogen - -		0·018	0·021	0·021	0·013	0·011	0·007	0·011
Nitric Nitrogen - - -		—	—	—	—	0·016	—	0·010
Carbonic Anhydride	Gasometric	47·306	47·813	47·798	48·508	49·918	—	48·701
Nitrogen - -		10·374	10·264	10·305	10·139	10·121	—	10·24
Oxygen - -		5·127	4·512	3·740	3·408	1·265	—	1·781*
Oxygen (Winkler)—Volumetric - - - -		5·01	4·28	3·66	3·47	1·21	4·71	2·25

* Indirect determination, as gas was lost after absorbing CO_2. The calculation was made by subtracting the mean volume of N. from the gas left after absorbing CO_2.

TABLE XLIX.—SERIES 3.

1 Per Cent. Belfast Sewage Mixed with: (*a*) Tap Water; and (*b*) Seawater. The Mixtures Saturated with Air at 60° *, 70° and 80° F. and Incubated in Full and Stoppered Bottles at these Temperatures.

(Dissolved gases expressed as cc. per litre at N.T.P. Other quantities as Parts per 100,000.)

Tap Water Mixture.	When Mixed.			After 5 Days at			After 14 Days at			After 42 Days at			Tap Water Alone.	Tap Water alone after 44 Days. at 60° F.
				60°	70°	80°	60°	70°	80°	60°	70°†	80°		
Ammoniacal Nitrogen		0·035		0·041	0·042	0·037	0·033	0·033	0·010	0·0006	0·000	0·026	0·0009	0·0008
Albuminoid Nitrogen		0·020		0·026	0·021	0·024	0·017	0·021	0·020	0·014	0·016	0·014	0·0104	0·0080
Nitrous Nitrogen		0·000		—	—	—	—	—	—	0·000	0·000	0·000	0·000	0·000
Nitric Nitrogen		0·022		—	—	—	—	—	—	0·072	0·055	0·023	0·025	0·013
Carbonic Anhydride } Gasometric	37·9	37·0	38·4	38·5	39·4	40·1	39·3	37·5	41·0	39·7	35·3	41·5	—	—
Nitrogen } Gasometric	13·3	11·9	11·1	12·9	11·9	11·1	11·1	12·8	11·9	12·8	12·2	11·1	—	—
Oxygen } Gasometric	6·2	6·0	5·4	5·0	4·1	3·0	4·2	4·2	0·9	2·9	7·1	0·2	—	—
Oxygen (Winkler) Volumetric	6·6	5·9	5·5	5·0	4·0	3·0	4·0	4·2	0·9	2·9	7·4	0·1	7·20	5·85
Sea Water Mixture.													Sea Water Alone.	Sea Water alone after 44 Days At 60° F.
Ammoniacal Nitrogen		0·041		0·036	0·040	0·042	0·048	0·033	0·035	0·043	0·036	0·024	0·0004	0·014
Albuminoid Nitrogen		0·018		0·018	0·017	0·017	0·020	0·020	0·018	0·012	0·013	0·014	0·005	0·006
Nitrous Nitrogen		0·000		—	—	—	—	—	—	0·00	D.T.‡	D.T.‡	0·000	0·000
Nitric Nitrogen		0·005		—	—	—	—	—	—	0·013	0·023	0·011	0·006	0·013
Carbonic Anhydride } Gasometric	47·7	47·25§	46·8	48·5	49·1	48·8	49·1	49·0	49·2	48·9	48·2	50·1	—	—
Nitrogen } Gasometric	1·4	10·45§	9·5	11·3	10·6	9·8	10·8	10·4	9·8	10·5	10·6	9·9	—	—
Oxygen } Gasometric	5·5	5·1 §	4·7	3·9	3·5	2·7	3·3	3·2	1·6	2·7	2·5	0·2	—	—
Oxygen (Winkler) Volumetric	5·7	5·4	5·0	4·0	3·6	2·8	3·2	3·1	1·5	2·5	2·3	0·1	5·83	4·89

* Some of the 60° bottles were actually kept at laboratory temperature, as the incubator would not hold them all.

† Green algæ developed in this bottle.

‡ D.T. = Doubtful trace.

§ Calculated mean of results at 60° and 80° F.

The following general conclusions seem warranted from the results of these experiments :—

(*a*) *Free Ammonia.*—In each of the three series, the analyses of the original mixtures show a distinctly greater yield of free ammonia in those containing seawater than in those containing tap water. Thus :—

	Seawater Mixture. N. as Free Ammonia. (Parts per 100,000.)	Tap Water Mixture. N. as Free Ammonia. (Parts per 100,000.)	Ratio of Free Ammonia in Seawater Mixture to that in the Tap Water Mixture.
Series 1 - - - - - -	0·030	0·017	176 : 100
,, 2 - - - - - -	0·030	0·018	166 : 100
,, 3 - - - - - -	0·041	0·035	117 : 100

Probably this effect is due to the action of the alkaline salts in the seawater on the nitrogenous matters of the sewage.[*] Obviously, this is a point of considerable importance when interpreting the results of analyses of polluted seawater samples, for if the amount of free ammonia be taken as the index of sewage pollution, as is frequently done, a given sample of seawater may appear to be much more highly polluted than a sample of fresh water containing the same proportion of sewage, and it may be nearly twice as much.

(*b*) *Albuminoid Ammonia.*—This did not diminish by more than about one-third of the original amount in either of the series after an interval of five to six weeks. Both the fresh and seawater mixtures behaved similarly as regards this factor, and temperature did not appear to exercise much influence on it in either mixture.

(*c*) *Dissolved Oxygen.*—The rate of disappearance of dissolved oxygen in four or five days at temperatures between 60° to 80° F. was very similar for both the sea and fresh water mixtures. Thus :—

Dissolved Oxygen disappearing in cc. per litre at N.T.P.

	Tap Water Mixture.	Seawater Mixture.	
(1)	1·5	1·4	5 days at 65° F.
(2)	1·1	1·4	4 ,, 80° F.
3)	1·2	1·6	5 ,, 60° F.
	1·9	1·8	5 ,, 70° F.
	2·4	2·0	5 ,, 80° F.

These results have a certain amount of importance, as it has been suggested that the salts of seawater interfere with the growth and inhibit at an early stage the development of the organisms present in sewage.

There is good reason for believing that disappearance of dissolved oxygen in polluted waters is largely, if not entirely due to micro-organisms : the process, in its earlier stages being analogous to respiration,and as a consequence, the oxygen becoming converted to a considerable extent into carbonic anhydride (as was indeed proved to be the case in our experiments), and if this is so, the disappearance of dissolved oxygen is an index to bacterial activity, which was therefore considerable in the periods mentioned above, and was practically the same in both the sea and fresh water mixtures. We are therefore of the opinion that the salts in seawater do *not* inhibit the first or " carbon " stage of fermentation occurring in such water when polluted.

The disappearance of dissolved oxygen after five or six weeks was distinctly greater in the tap water than in the seawater mixtures. Thus :—

Dissolved Oxygen disappearing in cc. per litre at N.T.P.

	Tap Water Mixture.	Seawater Mixture.	
(2)	4·6	3·8	5 weeks at 80° F.
(3)	3·3	2·8	6 ,, 60° F.
	4·5	2·9	6 ,, 70° F.
	5·2	4·5	6 ,, 80° F.

But it must be recollected that seawater saturated with air at a given temperature contains less oxygen than fresh water similarly saturated. Thus :—

One litre of seawater saturated with air at 60° *F. and* 760 *mm. contains* 5·8 *cc. dissolved oxygen at N.T.P.*

One litre of distilled water under the same conditions contains 7·2 *cc.*

Distilled water therefore contains over 22 per cent. more dissolved oxygen under these conditions than seawater.

But apart from this, the more rapid disappearance of dissolved oxygen from the tap water mixture is probably to be explained by differences in the behaviour of the two mixtures in respect of the second or " nitrogen " stage of fermentation which occurs in polluted waters.[*]

(*d*) *Nitrification.*—Thus, nitrification occurred to a decidedly less extent (under the conditions of these experiments) in the seawater than in the tap water mixtures. In the latter it commenced about the fourteenth day and was practically complete (in relation to the free ammonia originally present) in five weeks. While, on the other hand, the most favourable result with the seawater was the nitrification of less than one-half the free ammonia originally present.

Oxidised nitrogen was determined by the zinc-copper couple in all the samples, and while it is possible that the results in the case of the seawater mixtures were influenced by the Purvis-Courtauld effect, already referred to, the error, if introduced at all, would probably be the same in all the determinations, and would therefore, not affect the results in relation to the gain in nitrates. (*See* p. 120.)

G. Fowler [†] concluded that only the stage of nitrite formation is reached when seawater is incubated with sewage sludge, even after seven months. Adeney [‡] (*loc. cit.*) came to the same conclusion in comparative experiments with 20 per cent. mixtures of sewage and tap water on the one hand, and seawater on the other, the experiments being carried out under aerobic conditions over a period of fifty-three days, while Purvis, in collaboration with others,[§] also observed the production of nitrites in incubated samples of seawater polluted with sewage.

A careful examination was made at the end of the experiments in Series 3 for nitrites in all the samples, but we could only find what we have recorded as " doubtful traces " in two of the seawater mixtures.[‖] As this matter is one of some importance, and the results obtained in the above experiments were not conclusive, further experiments were made which we shall describe presently.

(*e*) *Effects of Temperature.*—Regarding the effects of temperature on the nature and speed of the chemical changes occurring in the polluted mixtures experimented with, there can be no question that the amount of dissolved oxygen disappearing was greatest throughout the experiments at 80° F., the highest temperature employed, least at 60° F., the lowest temperature, and intermediate at 70° F., in both the seawater and fresh water mixtures.

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[*] Reports of Royal Commission on Sewage Disposal, Cd. 1886, IV., Methods of Analysis, p. 59.

[*] Adeney (Appendix VI. to Fifth Report of Royal Commission on Sewage Disposal, p. 55) experimented with 20 per cent. mixtures of sewage with both tap and sea-water under aerobic conditions, and his results in relation to the absorption of dissolved oxygen agree to a considerable extent with those obtained by us.

[†] Appendix VI. to Fifth Report of Royal Commission on Sewage Disposal, p. 555.

[‡] *Ibid.*, p. 436.

[§] Paper read before the Section of Hygiene at the International Congress of Applied Chemistry, London.

[‖] *See* remarks on p. 106, relative to the delicacy of the different tests employed for detecting and estimating nitrites.

But it is difficult to say whether nitrification was promoted or retarded by increase of temperature.

In the third series of experiments with the tap water mixture, the latter effect was observed, while with the seawater mixtures, the results were irregular and the experiments not continued long enough to be conclusive.* At the highest temperature, the exhaustion of the oxygen by the "carbon fermentation" was quite possibly too great to allow of the subsequent "nitrogen fermentation," and also the amount of dissolved oxygen originally present, was lowest.

At 60° F. not only was more oxygen present originally, but the results show that after a fortnight or so, both kinds of fermentation proceeded together, so that it is conceivable that the relative powers of the two classes of micro-organisms concerned were more evenly balanced. If such were the fact, it may involve a practical point of some importance, for in the case of a water continuously polluted in warm weather, the whole of the available oxygen may be used up in carbon fermentation as fast as the water is naturally aërated, and nitrification as a consequence be impeded.

In colder weather, on the other hand, nitrification may proceed more rapidly or with greater ease.

The fact that green *algae* are most abundant in water at the time of the year when the former conditions prevail may perhaps be a provision of Nature's to balance matters, since by the absorption of ammoniacal nitrogen these *algae* would prevent an excess of unoxidized nitrogen from accumulating in the water, while the *algae* would also arrest or prevent putrefactive changes by supplying an abundance of dissolved oxygen.

In view of the somewhat doubtful results obtained on the one hand in the experiments just described, as regards the formation of nitrites and nitrates in the seawater mixtures, and of the more positive results obtained by Adeney and Fowler on the other, it was decided to make further experiments on the subject.

The chief question to be answered was this—Do the nitrogenous constituents of sewage and especially the free ammonia, become oxidised in the presence of an excess of seawater to nitrous or to nitric acid? It will be recalled that we had definitely proved the presence of *nitrates* in the majority of the samples of pure seawater which we had examined, and the absence of *nitrites*, so that the probability seemed to be that eventually, if not immediately, the oxidised nitrogen in polluted seawater would appear as nitrate.

As the question of dissolved gases, as well as that of temperature, were, we deemed, of no special importance in this matter we did not determine the first, and as regards the second, for the sake of convenience our experiments were conducted at ordinary temperatures. Lastly, in order to have fairly large amounts of products, we employed a mixture of 5 per cent. sewage and 95 of seawater instead of the 1 per cent. mixture used in our previous experiments, and we worked under aerobic conditions. For reasons given elsewhere (p. 105) the brucine test was relied on for indicating traces of oxidised nitrogen generally, and later the potassium iodide and starch test was used for showing the presence or absence of nitrites in more minute quantities than can be recognised by the metaphenylene diamine reaction.

The results of this series of experiments are given in the following table :—

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* Purvis, McAlister and Minnett (*loc. cit.*) express the opinion that "nitrifying organisms do not work efficiently in the presence of warmth," but, on the other hand, nitre occurs abundantly in hot countries.

TABLE L.—SERIES 4.

FIVE PER CENT. BELFAST SEWAGE MIXED WITH SEAWATER AND KEPT IN HALF-FULL BOTTLES AT LABORATORY TEMPERATURE.

BOTTLES UNSTOPPERED AND SHAKEN AT INTERVALS.

(All quantities expressed as parts per 100,000.)

	When Mixed. (July 1st, 1910.)	After 12 Days.	After 21 Days.	After 27 Days.	After 73 Days. (Sep. 11th.)	After 103 Days. (Oct. 11th.)	After 167 Days. (Dec. 14th.)	After 198 Days. (Jan. 14th, 1911.)
Ammoniacal nitrogen	0·12	0·16	0·15	0·15	0·019	0·000	0·001	—
Albuminoid ,,	0·10	0·08	0·06	0·06	0·024	0·018	0·021	—
Nitrous ,,	None	None	0·005†	0·002†	0·114	0·131	None	None.
Nitric* ,,	None	None			0·011	0·009	0·128	—
Sum of the above	0·22	0·24	0·215	0·212	0·168	0·158	0·150	—
Brucine test	Not used.	Not used.	Distinct yellow coloration.	Very doubtful coloration.	Bright pink changing to yellow.	Pink to yellow.	—	—
Starch and potassium iodide test	—	—	—	—	Strong reaction.	Strong reaction.	No reaction.	No reaction.

* By zinc-copper couple.
† As the starch-iodide test was not used, we cannot say to which form this oxidised nitrogen should be assigned.

The results are very interesting.

It will be seen that small quantities of oxidised nitrogen began to be formed about the third week probably as nitrous nitrogen. The latter appeared, however, in considerable amount after seventy-three days and increased materially during the next month. In the first of these two latter periods the nitric nitrogen had increased slightly, with apparently slight decrease during the second. Finally, after five and a half months every trace of nitrous nitrogen had disappeared, while nitric nitrogen had largely replaced it.

We say "had largely replaced it," because as will be seen, the total quantity of nitrogen (as measured by the four factors named in the table) steadily diminished after the first twelve days—the final loss amounting to nearly 30 per cent., if the total nitrogen found in the original mixture be taken, or to rather over 38 per cent. if the amount found on the twelfth day be taken instead.

It is difficult to see how this nitrogen can have been lost unless in the gaseous form, that is to say by a process of denitrification or denitrosification.

Finally, attention may be drawn to the fact that the greatest changes occurred between the twenty-seventh and the seventy-third days, except of course the conversion of nitrite into nitrate, which probably occurred much later.

10.—THE RELATIONS OF ULVA TO MUSSELS.

In a former note on this subject, attention was drawn by one of us to the fact that any relatively large fronds of *Ulva* found on the Belfast foreshores in a fixed condition, are almost always anchored by mussels; the latter throwing out very tough threads (the so-called "byssus" threads), by which they attach themselves to the former, and as a rule at the same time and by means of other of these threads attach themselves also to some fixed support such as a stone or other mussels.

Ulva thus anchored, can resist considerable wave action and remains *in situ*. Even under very strong wave action, the attachment holds to some extent. Thus during the autumn of 1909, after a heavy gale from the North East (wind from which quarter brings the highest waves to be met with in Belfast Lough) one of us noticed the remains of what had been, previous to the gale, growths of *Ulva* fronds of considerable area adhering to mussels, the latter still remaining attached to their main support.

Our impression is that it may be safely assumed that at least 90 per cent. of the attached *Ulva* fronds on the sloblands of Belfast Lough are thus fixed by mussels and held *in situ*.

At the time of writing the previous note on the subject, it was suggested that this fixation of the seaweed by the mussels was probably no mere accident, but was quite possibly of the nature of a symbiotic process whereby both the animal and the vegetable benefited.

The mussel which is so often found in polluted waters, would obtain an abundant supply of dissolved oxygen in the immediate neighbourhood of the *Ulva**.

Moreover, fragments of *Ulva* are frequently found in the stomachs of mussels, so that apparently it is an actual foodstuff for these bivalves; and they would therefore derive a double benefit from the *Ulva's* neighbourhood.

It was also suggested that mussels in their turn might be of service to the *Ulva* by supplying it with ammonia from their excrements (or from decomposition of their tissues, in the event of the animal's death).

Since the first note on these matters was written, the importance of the whole question has been more fully realised, and not only has the suggestion been made that it may be possible to materially abate the *Ulva* nuisance, by clearing the mussel beds away from the foreshores, but extensive clearances of these beds have been made on the Co. Down foreshore, with, as far as can be judged, very good results.

Before this had been done, however, it had occurred to us that it was worth while to study the relationships of mussels to *Ulva* in the laboratory.

The following experiments were therefore made :—

(1) Do Mussels Evolve Ammonia ?

Experiment 1.—Two mussels—each about 2 inches in length—were carefully washed under the tap and placed in 500 cc. of seawater in a stoppered glass cylinder.

The water was poured off three days later, and free ammonia determined both in it and in the original seawater, with the following results :—

	N. as ammonia. Parts per 100,000.
Original seawater - - - - -	0·0055
After contact with mussels - -	0·0210
Increase - - - - -	0·0155

Experiment 2.—The same mussels were treated precisely as before, for a further period of three days, but a different sample of seawater was used. The following results were obtained :—

	N. as ammonia. Parts per 100,000.
Original seawater - - - - -	0·002
After contact with mussels - -	0·115
Increase - - - - -	0·113

Experiment 3.—Two other mussels, of similar size to those used in the first experiments were treated in the same way as before, for three days, using a fresh sample of seawater. The results now obtained were as follows :—

	N. as ammonia. Parts per 100,000.
Original seawater - - - - -	0·0015
After contact with mussels - -	0·0425
Increase - - - - -	0·0410

The above experiments were sufficiently conclusive. Mussels, no doubt by their excrements, evolve considerable quantities of ammonia.

Taking the mean of the above results in round numbers, a single mussel when living, adds during twenty-four hours, an amount of ammonia to half a litre of seawater equivalent to ½ per cent. Belfast sewage.

It seems to us, however, that the really important point brought out by these experiments is, *that through the vital processes of mussels albuminoid matters are converted into ammonia, and may ultimately be absorbed by Ulva in that form.*

(2) Do Mussels Deliberately Attach Themselves to Ulva ?

We are informed by Professor Gregg Wilson that adult mussels which have spun their *byssus* threads, and by means of them have attached themselves to a given support, are unable to detach themselves, and cease therefore to have locomotory powers.

But if the *byssus* threads are cut, the mussels are able to move by means of their "foot"—a worm-like organ of some length, which they project from between their shells, and by its means push themselves along.

The plan of experiment which suggested itself, was to take an attached mussel—preferably one attached to *Ulva*—to gently detach it by cutting the *byssus* threads, then to place it in a glass tank filled with seawater containing fronds of *Ulva* at some distance from it and to watch its proceedings.

Unfortunately, mussels when thus detached, are often very slow and uncertain in their movements—at all events when kept under artificial conditions of the kind mentioned—and for exact observations it would be necessary to keep them continuously in view for several days in succession. The time at our disposal did not permit of our doing this in the experiments we tried, and we could only look at them occasionally. The net results of our observations were as follows :—Some eight or nine mussels were experimented with at different times, and of these, three or four were often in the same dish. Some neither moved nor spun any threads, but merely opened and closed their shells from time to time in what we had learnt to regard as the normal or healthy manner.

Two or three we saw moving, and in all, five attached themselves by their *byssus* threads.

Four of these five attached themselves to both the glass dish and to Ulva fronds, and one travelled a considerable distance towards the Ulva and then upwards on the side of the glass until it reached the seaweed to which it also attached itself.

The experiment of detaching mussels from both their support and from *Ulva* fronds, and then placing them in glass dishes containing seawater and loose *Ulva* has been repeated two or three times, with results entirely similar to those just described, and we are therefore of the opinion that mussels *do deliberately attach themselves to Ulva fronds*, and very probably for the reasons mentioned.

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* On p. 165 of Appendix VI. to the Commission's Fifth Report an experiment is described in which during four hours contact of *Ulva* with sea-water polluted with ammonium chloride, 5·79 c.c. of carbonic anhydride per litre of the water disappeared, with a probable evolution of a similar volume of oxygen.

If the mixture had been free from dissolved oxygen to start with, it would have become suitable—so far as oxygen content is concerned—for the respiration of marine animals, at the end of the four hours.

* * * * *

Two points of practical importance arise from these observations. In the first place, *Ulva* is a plant which grows, not only when attached by its own root or when anchored by mussels, but also (as we have shown), if a frond is cut into pieces, each of these latter continues to grow when placed under suitable conditions—behaving in fact as a separate plant.

Consider now the case of a frond anchored by a mussel. It continues to grow—and how rapid that growth may be will be seen from our experiments, more especially those made in the Timber Pond Channel Bay—until it reaches a certain size, beyond which it can no longer resist the battering action of the waves.

Part then becomes detached—it may be in one piece, it may be in several. What remains in attachment to the mussel continues to grow until the same thing occurs again, while the detached piece or pieces may be either driven ashore or become attached to other mussels.

In this way, therefore, *a mussel bed may become an Ulva nursery without any spore formation on the part of the seaweed at all.* For these reasons it seems probable: (1) That the sloblands between the Connswater river and the Kinnegar, which until quite recently were covered with mussel beds and attached *Ulva*, formed, if not the chief nursery of *Ulva* in Belfast Lough (which we are inclined to believe was the case), at least one of the chief nurseries.

Also (2) it seems obvious that by clearing these mussel beds away, the growth of the seaweed may be materially abated.

NOTES.

(1) *The Food of Mussels.*—The following note as to the food of mussels has been kindly supplied us by Mr. W. J. Dakin, M.Sc. :—

"Sabatier found in the stomachs of sixty-two *Mytilus edulis* :—

Diatoms (twenty species are enumerated).
Sponge spicules.
Half digested small crustaceans.
Remains of Ulva.
Filaments of Bangia.
Spicules of Gorgonids.
Infusoria.
Eggs of lower organisms.
Small *larvæ*, etc."

Several of the above would, no doubt, find their food supplies in both sewage solids and decaying *Ulva*. Mussels, therefore, provide an indirect mechanism for converting both of these latter into nutriment for living *Ulva*.

(2) *Locomotion of Mussels* :—

"There is in many *Conchifera*, a curious organ known from some of its functions as the foot. It is a muscular mass, frequently of great size, and capable of being pushed from between the mantle and valves to a long distance. It sometimes acts as a pushing pole. . . . In other species the foot is grooved; and being associated with a gland which has the power of secreting a glutinous substance, the latter is drawn out by means of the groove into slender threads, which are attached by their tips to the rocks and other foreign bodies. The grooved foot is then withdrawn, and the thread hardens into a very strong, highly elastic sort of silk, called *byssus*. It is by the aggregation of many such threads that the common mussel (*Mytilus*) moors itself to the rocks and to its fellows."—(Gosse's *Marine Zoology*.)

11.—UTILIZATION OF *ULVA*.

Some experiments have been made with a view to the practical utilization of *Ulva*, either directly as a manure after drying and powdering, or indirectly by distilling the seaweed and recovering the ammonium sulphate and products such as potassium sulphate from the "coke."

(1) DRYING UNDER DIFFERENT CONDITIONS.

The raw weed as collected contains from 80–90 per cent. of water. To move it any distance in this condition is obviously uneconomical: nevertheless it is so removed by the farmers of the neighbourhood in increasing quantities and they have evidently learnt by experience its admirable qualities as a manure.

We find that if the seaweed is spread out in thin layers, not more than two fronds deep on a sloping bank, the moisture is reduced to 24 per cent. in ordinary fine weather in a few hours. While if it is previously rinsed in fresh water to remove the hygroscopic salts of the seawater adhering to it, the moisture can be reduced to 13 per cent. by drying as just described. This is without the use of any artificial heat. In this state *Ulva* could be pressed hydraulically into bales and would then be suitable for transport. Also it can then be readily pulverized and might be sold as powder. It would be well if some authoritative experiments could be made as regards the precise value of *Ulva* as a manure for different classes of soil and crops.

(2) DISTILLATION OF ULVA WITH AMMONIA RECOVERY.

The feasibility of this process was first suggested by one of us in reports to the Belfast Corporation and also in Appendix VI. to the Commission's Fifth Report (p 154).

For the purpose of distilling *Ulva* on a working scale, the Gas Department of the Belfast Corporation very kindly lent us the necessary apparatus.

The retort, which was heated by gas burners, would take a charge of 1½ lbs. of dry *Ulva* when at a working heat. The ascension pipe from the retort was joined to up, an iron tube air condenser, which, as originally fitted had six vertical branches, but experiments soon showed that a single one of these was more than sufficient to condense nearly all the volatile matters (*i.e.* liquids) coming over. At the bottom of the condenser pipe a cock was fitted, through which the tar and ammoniacal liquor could be run off.

From the condenser, the gas was led into an ammonia absorption box, consisting of a lead lined tank containing 10 per cent, sulphuric acid. The gas bubbled through the acid and passed on to the gas holder. The latter had a capacity of 10 cubic feet and was adjusted with counterweights, so as to keep a slight vacuum of 2 inches of water on the absorption box.

In all, one cwt. of dry *Ulva** was distilled in this apparatus, which behaved very satisfactorily throughout the experiment.

In fitting up the plant, and during the experiment we were advised and assisted by Mr. Hoskins, chemist to the Gas Department of the Belfast Corporation, to whom we are very greatly indebted.

In this experiment, the objects we had in view were to determine :—

(1) Volume and nature of the resulting gases.

(2) Weight of ammonia produced.

(3) Weight and nature of the tar produced and its examination for useful products.

(4) Weight and nature of the "coke" remaining and its examination also, for useful products.

(*a*) *Gases.*

These came off rapidly on first putting the charge of *Ulva* into the hot retort, but the last cubic foot was evolved very slowly. Each charge of 1½ lbs. of dry seaweed yielded about 5·2 cubic feet if pressed to the last, but in practice each charge was run until 4½ cubic feet were in the holder.

The gas was combustible and burnt with a very hot and almost non-luminous flame. It had an exceedingly repulsive smell causing headache even when inhaled in small amount. After each charge, the gas was blown off through a pipe into the open air. Samples of gas collected in sealed glass tubes gave the following figures when analysed :—

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* This actually contained 5 per cent. of moisture after drying in a warm room.

	Ulva gases. Volumes Per Cent.	
	I.	II.
Carbon dioxide	17·4	29·6
Oxygen	0·5	0·0
Nitrogen	20·2	11·1
Hydrogen	24·3	37·1
Carbon monoxide	17·7	15·7
Methane	19·9	6·5
	100·0	100·0

I.—Charged hot. (After 3 charges had been run through.)

II.—Charged hot. (After 1 charge had been run through.)

(*b*) *Weight of Ammonia Produced.*

On examining the dilute sulphuric acid in the absorption box, which had been tested from time to time to see if it had been neutralized, *no* ammonia was found. This result was not unexpected, because the tarry liquor collected from the single condenser pipe smelt strongly of ammonia. When separated as completely as possible, this liquor amounted to 1,209 cc. of tar and 10,125 cc. of ammoniacal liquor which was very brown. Both smelt strongly of pyridine. The ammoniacal liquor was carefully sampled and a portion distilled into sulphuric acid. It was soon found that substances other than ammonia were passing over as the acid rapidly became brown. The ammonium sulphate crystallized out from this was dirty and smelt of pyridine. The yield was about 1 oz. of sulphate from 1 lb. of dry *Ulva*.

In order to get rid of this brown colour, the method was modified somewhat. The ammoniacal liquor was neutralized with sulphuric acid, which caused a violent effervescence. It was then filtered through a considerable quantity of powdered *Ulva* " coke " or residue from the distillation retort. This powdered " coke " had been well extracted with water previously. The filtrate was still rather brown in colour but clear. The ammonium sulphate crystallized from it was not so strongly coloured as the first sample, but was still somewhat dirty.

The only way in which a clean white sulphate could be obtained, was by distilling the coke-filtered liquor into sulphuric acid and then crystallizing out. This yielded an almost white sulphate.

It is evident that the temperature of distillation of *Ulva* and the methods of condensing and separating the tarry matters, would require to be very carefully adjusted so as to avoid the contamination of the ammoniacal liquor as much as possible.

In the experiment performed by us, the retort was not heated much beyond a dull red, as the gas supply was limited owing to its passing through too small a meter; also the condenser was probably too large. It should have condensed the tar and allowed the ammonia and steam to go on into the absorption box. The difficulty here was the light nature of the tar and its low boiling point Perhaps with a hotter retort, some of the lighter portions of the tar would have been " cracked up " and thus have produced a cleaner separation of tar and ammonia. As things were, instead of getting 3 ozs. of ammonium sulphate from 1 lb. of *Ulva* which is the theoretical yield if all the nitrogen had been recovered, barely 1 oz. was obtained.

(*c*) *Ulva Tar.*

The time at our disposal has only permitted of a very superficial examination of this material.

It had a very strong odour of pyridine; 400 grammes when distilled yielded the following with weights as shown :—

80—105°	Oil	27	grammes.
	Watery	19	„
105—200°		33	„
200—300°		121·5	„
Above 300°		199·5	„

A good deal of ammonia came off at high temperatures and a solid was deposited in the condenser which was found to consist of ammonium carbonate.

The volatile fractions treated first with a solution of sulphuric acid (to remove bases) and then with one of caustic potash (to remove phenols), were then repeatedly, but not exhaustively fractionated. The fractions then obtained showed maxima at the following temperatures :—

80—100° C.
130—140° C.
190—215° C.

(*d*) *Weight and Nature of the Coke remaining in the Retort.*

The coke left in the retort was of a very light friable nature and therefore easily reduced to powder.

From 1 cwt. of *Ulva*, the coke produced was 54 lbs.

Its calorific value was ascertained to be 640 centigrade units, or one-twelfth that of good coal.

Soluble Constituents.—These together with the carbon, would, in all probability, be the only commercially valuable parts of the coke. Regarding the soluble constituents, the following experiments were made :—

(*a*) *Preliminary.*—On treating 50 grammes of the coke with about ten times its weight of boiling water in three successive quantities and evaporating the combined extracts to dryness, the residue weighed 7·6 grammes or 15·2 per cent.

Qualitative analysis having shown that the salts thus dissolved out consisted chiefly of calcium, sodium and potassium combined with sulphuric acid and chlorine, it was decided to separate these salts as far as possible by fractional crystallisation in order to ascertain of what they really consisted. Accordingly :—

(*b*) Another experiment was performed in which 300 grammes of the coke was repeatedly extracted with boiling water, the solution filtered, evaporated to small bulk on a water bath, and then allowed to evaporate at ordinary temperatures. The general results then obtained were :—

(1) The separation of a less soluble salt which from its qualitative analysis and crystalline form appeared to be the double sulphate of calcium having the formula $2CaSO_4$, $Na_2\,SO_4$, $2H_2O$.

(2) The separation after this salt of cubical crystals which gave the reactions of sodium chloride.

(3) The mother liquors from these, from qualitative tests appeared to contain only potassium sulphate in addition to some more sodium chloride, and gave apparently crystals of potassium sulphate on further evaporation at ordinary temperatures.

(4) A portion of the same mother liquors was also examined for iodine, the presence of which had not been ascertained previously, though sought for. A more careful examination now made, showed that its detection was somewhat difficult, because of the occurrence of sulphides in addition to iodides, so that on adding chlorine water, the chlorine was first used up in oxidising the former, while owing to the minute amount of the latter present, oxidation of the liberated iodine readily occurred on adding even a very slight excess of chlorine water. However, by adding the latter very cautiously to a mixture of the mother liquor and chloroform, and shaking after each addition, the characteristic violet layer was eventually obtained.

With regard to the commercial success of a process for manufacturing ammonia from *Ulva*, it must be clear (that apart from the potassium sulphate) there could not be much profit on the yield of ammonia actually obtained in the experiment described above. Ammonium sulphate fetches £11 odd per ton, and 16 tons of dry *Ulva* would yield 1 ton of the sulphate. Therefore about 160 tons of wet *Ulva* would have to be collected, dried, distilled, the ammonia recovered and put on the market at a cost of less than £11, if any profit were to be made. The use of any ordinary fuel, even of the cheapest kind would be prohibitive, but it might be perfectly feasible to utilize : (1) The gas arising from the distillation of the *Ulva*; and (2) water-gas from the resulting coke, with or without the addition of extraneous combustible matter, and possibly thus to reduce the bill for the latter to a very small quantity.

We had indeed hoped to have made an experiment on this point with a small " producer " plant at the Belfast

Municipal Technical Institute, which the authorities were, we understand, prepared to place at our disposal, but we have had no time to do so. It is possible that under the conditions of combustion in a plant of this kind, more of the nitrogen in *Ulva* would have appeared as ammonia than in the experiment which we have described.

We may mention that it is a fact that ammonia recovery processes are in successful operation, in which the raw material (coal or peat) contains under 2 per cent. of nitrogen.

One pound of coal requires 2·3 cubic feet of its own gas to distil it; 1 lb. of *Ulva* yields 3 cubic feet of low quality gas (actual calorific value not yet determined, but is probably less than half that of coal gas).

The cost of ammonia recovery is said to be about £15 per 100 tons of fuel distilled, on a 2 per cent. nitrogen basis. This includes sulphuric acid, labour and sundries. If, therefore, only one-half of the nitrogen in *Ulva* were recovered as ammonia, there would be a surplus of about 17s. per ton from which the cost of collection, drying and fuel would have to be deducted. If the fuel bill could be reduced in the way suggested, there should be a margin of profit. As a large sum (£1,500) is spent annually by the Joint Board in collecting and disposing of the cast up seaweed, some portion of this cost might well be recovered by means of ammonia production, coupled with that of potassium sulphate.

It may be mentioned in this connection that the actual amount of wet *Ulva* collected by this Board amounts in one year to some 27,000 tons, which from the results of our experiment, is capable of yielding ammonia of the value of some £1,848.

In concluding this section we may give the following:—

RESULTS OF EXPERIMENT ON THE DISTILLATION OF ULVA CALCULATED AS THE WEIGHTS, ETC. OBTAINED FROM 1 TON CONTAINING 5 PER CENT. OF WATER.

Volatile Products.

Gas	- say	6720 Cubic Feet. (Value ?.)
Tar	- say	5·3 Gallons. (Value ?.)
Ammoniacal liquor	- say	44·6 gallons containing ammonia equivalent to 140 lbs. (Value, say 13s. 9d.)

Fixed Products.

"Coke" - say 9·6 cwt. containing	-	Soluble salts, 13·2 per cent. = 141·9 lbs. containing 35·5 lbs. potassium sulphate. (Value, say 11s. 10d.) Carbon, 21·3 per cent. = 229·0 lbs. Insoluble salts, 65·5 per cent. = 704·1 lbs.

12.—NOTE ON A VISIT TO THE SOUTH OF ENGLAND IN RELATION TO THE GROWTH OF *ULVA*.

VISIT TO STUDLAND BAY, SWANAGE AND WEYMOUTH.

In company with Mr. Cotton, we visited these localities on November 2nd and 3rd, 1910, devoting that part of the first day which remained after the journey from London had been made, to:—

Studland Bay.—We purposely arrived at low (spring) tide and collected a sample of seawater below the village. This we did in order to ascertain the extent of the pollution caused by decaying seaweeds, of which there was an abundance,* and also that caused by a small stream of fresh water. It will be seen from the analysis† of this sample that nitrates were present in some quantity.

We then took a boat and rowed to that part of the cliffs which Mr. Cotton informed us had been visited by the Commission in the previous September and where abundance of *Ulva* was then seen.

We certainly found it growing in some of the rock pools here, but it was not abundant and we had some difficulty in collecting sufficient to fill Mr. Cotton's *vasculum.* The samples collected were much darker in colour than those obtained by the Commission and on analysis were found to contain a higher proportion of nitrogen.‡ Also only small fronds could be found, whereas the Commission obtained several of large area. We may mention that Mr. Cotton was much struck with the diminution in the quantity of the seaweed since his last visit, which was in company with the Commission.

The second sample of water was collected from a rock pool in which *Ulva* was growing. Its chief feature was the remarkably high proportion of nitric nitrogen which it contained (equivalent to one-eleventh of the ammoniacal nitrogen of the Belfast sewage).

The third sample of water was collected from another rock pool near by, fed by drainings from rotting seaweeds, and we may mention that all along the face of the cliffs there were large quantities of drift weed and in places the sands were black and stinking. As might have been expected this sample contained a high proportion of albuminoid nitrogen, otherwise it did not appear be to impure.

The general impression we formed of the localities in Studland Bay where *Ulva* occurred, was that they were subject at times to considerable natural pollution—sufficient in all probability to account for the growth of a good deal of that seaweed.

Swanage.—One of us walked with Mr. Cotton along the cliff path to Durlston Head and descended to the rocks below. The tide was however high and the sea rough, so that no useful observations could be made. No *Ulva* was seen.

Weymouth.—We may refer to Mr. Cotton's Report, p. 130, for a full description of this locality and especially of the Lake or Backwater. Our attention was almost entirely devoted to the latter. We walked along its eastern shore to its junction with the Wey river. Practically the only marine vegetation seen was *Ulva*, of which there were large quantities, and it was being collected for removal or had been collected at several points. We estimated that between *ten* and *twenty* cart-loads had been thus gathered.*

We noticed a large number of swans and gulls busily feeding in two long lines, but could not ascertain the nature of the food they were getting. Gulls we have often seen feeding among *Ulva* and turning it over to get at the small crustaceans which frequently abound in it. We happened to come across some swan's excrement which was quite green and looked as if it consisted largely, if not entirely of *Ulva*.

Dr. W. B. Barclay the M.O.H. for Weymouth, whom we met, was of the opinion that the Backwater is polluted with sewage from Weymouth. It also receives the waters of the river Wey, as already mentioned, and these are undoubtedly polluted as the analyses of samples collected by Dr. Barclay after our visit, show. These are given below:—

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* These consisted of Laminaria, Zostera, Red weeds, etc., which were high up on the sands and also imbedded in the sands.

† *See* p. 108 for the analyses of all the samples of water collected on this occasion.

‡ Percentage of Nitrogen: Two samples, (*a*) 3·65; (*b*) 3·53. Ditto of sample collected by the Commission, 1·18.

* A sample of this weed gave 3·84 per cent. of Nitrogen.

SAMPLES OF THE WATERS OF THE RIVER WEY, WHICH ENTERS THE BACKWATER AT WEYMOUTH, WHERE MUCH "ULVA" OCCURS AT TIMES. THE SAMPLES WERE COLLECTED BY DR. BARCLAY, M.O.H. FOR WEYMOUTH, IN NOVEMBER, 1910.

(The samples were analysed by Dr. McGowan.)

(All quantities expressed as parts per 100,000.)

	At Radipole Bridge at Low Water. (Should be no Tidal Water.)	Above Millar Weir, Radipole.	Above Village of Radipole. And Below Village of Nottington.
Ammoniacal nitrogen	0·015	0·014	0·010
Albuminoid nitrogen	0·034	0·059	0·022
Nitric nitrogen	0·240	0·180	0·252
" Oxygen absorbed " $\frac{N}{80}$ KMnO$_4$, after 4 hours	0·297	0·656	0·214
Chlorine	9·10	4·00	3·48
Solids by centrifuge	6·3	68·8	4·4
Oxygen when analysed	1·01	0·95	1·02
Oxygen taken up in 5 days	0·18	0·25	0·09
Remarks	Rather opalescent. Considerable fine suspended matter. No smell.	Very turbid with much fine light suspended matter. No smell.	Slightly opalescent. Little fine light coloured suspended matter. No smell.

The samples of water collected during the Commission's visit to Weymouth, had been all drawn from the Backwater. They contained but little ammoniacal nitrogen, while on the other hand the albuminoid nitrogen was somewhat high.

As *Ulva* absorbs ammonia rapidly from a polluted water, these analyses are not inconsistent with the view that the Backwater receives an appreciable amount of sewage pollution.

13.—EXPERIMENTS WITH *ULVA* FROM STUDLAND BAY AND FROM BELFAST LOUGH.

The collection in November, 1910, of a quantity of *Ulva* from Studland Bay, a locality free at all events from sewage pollution, gave us an opportunity which we had desired, of contrasting the behaviour of such *Ulva* with that from Belfast Lough which is polluted with sewage. There were several directions in which we were desirous to carry out experiments, such for instance as :—

(1) What will be the rate of growth of *Ulva* from a place like Studland Bay: (*a*) In pure seawater; and (*b*) in seawater polluted with sewage, such as is found in Belfast Lough, also (*c*) how will the growth under these conditions compare with that of *Ulva* from Belfast Lough under similar conditions ? *

(2) *Ulva* from places like Studland Bay, (frequently at least) contains a higher proportion of sulphur (as sulphates) than that from polluted districts like Belfast Lough. Will the seaweed of the first kind ferment in the same way as that of the latter and will it cause the evolution of a proportionally larger amount of sulphuretted hydrogen ?

Unfortunately we have only had a very short time in which to attack these different problems, but a certain amount of progress has been made and some very interesting results have been obtained.

(1) GROWTH EXPERIMENTS IN GLASS DISHES.†

(*a*) *As Measured by Increase in Area.*

As the weather was now wintry and the room in which the experiments were made, was one with a northerly aspect, it was considered advisable to heat the glass dishes. This was done by means of a very small gas flame at a distance of about 8 inches under each dish (which latter was supported on a tripod stand). In this way a temperature was maintained in the water of each dish which ranged between 61° and 71° F.

The Studland *Ulva* was collected as already stated on November 2nd, 1910, and was sent by post to Belfast where it was at once placed in seawater.

The Belfast Lough *Ulva* was collected on November 9th, 1910, from the rocks at Cultra, all being young fronds attached to the rocks by their roots. Both sets of fronds were carefully selected for this experiment. Three of each were measured (as described on p. 75) and were then placed in glass dishes, together with 3 litres of seawater,‡ and the dishes covered with glass plates. The seawater was renewed twice each week.

These experiments were commenced on November 15th, 1910, and the following figures show the percentage increases in area which have occurred since then :—

Fronds.	Percentage Increase in Area.					
	Studland *Ulva*.			Belfast *Ulva*.		
	I.	II.	III.	I.	II.	III.
December 13th, 1910	11	12 (Mean 8·3)	2	38	22 (Mean 31·3)	34

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* It will be seen that only part of this programme of work was carried out, the time at our disposal being insufficient for its completion.

† These were the same as those previously used at the pumping station for a similar purpose.

‡ The Studland *Ulva* was fed with pure sea-water from the Irish Channel series (*a*) or (*b*). The Belfast *Ulva* with that from Belfast Lough collected at the New Sludge Jetty in the Seal Channel.

These results clearly show the effects of pollution in encouraging the growth of the Belfast seaweed.

(*b*) *As Measured by Changes in Weight.*

Fifty grams of the *Ulva* fronds, collected from Studland Bay and carefully selected, were drained (previous to weighing, as described on p. 90) and placed in one of the glass dishes containing 3 litres of pure seawater (Series A. or B. (*see* p. 105), while 50 grams of Cultra *Ulva* also carefully selected and drained before weighing, were placed in another dish containing 3 litres of Belfast Lough water (collected at the new Sludge Jetty).

The water of both dishes was renewed twice weekly, and the ammoniacal nitrogen determined in each sample both before and after remaining in contact with the seaweed, as we thought the opportunity might be utilized for determining ammonia absorption along with the changes in weight.

The following results were obtained :—

Changes in Weight.

	Studland *Ulva.* (In Irish Channel water.)	Belfast *Ulva.* (In Seal Channel water.)
November 14th, 1910	50 Grams.	50 Grams.
November 21st, 1910	45 ,,	50 ,,
November 29th, 1910	49 ,,	53 ,,
December 13th, 1910	43 ,,	52 ,,

These results agree with the previous weight experiments, that is to say that there is a *fall* in the weight of the samples grown in pure seawater and a *rise* in that grown in the polluted water.

The changes are however small, probably owing to the season not being favourable, more especially as regards light.

AMMONIA ABSORPTION BY ULVA AFTER 3—4 DAYS.

	N. as Ammonia at Start. (Parts per 100,000.)	N. as Ammonia at Finish. (Parts per 100,000.)
(1) Studland *Ulva* in pure Seawater (Irish Channel)	(1) 0·011*	0·001
	(2) 0·002	0·001
	(3) 0·002	0·008
	(4) 0·002	0·003
	(5) 0·004	0·001
	(6) 0·004	0·005
(2) Belfast *Ulva* in polluted Seawater (Seal Channel)	(1) 0·028	0·003
	(2) 0·028	0·003
	(3) 0·028	0·004
	(4) 0·028	0·020
	(5) 0·032	0·002

* A sample from Blackhead. All the samples obtained from this place lately have contained notable quantities of free ammonia, which we cannot explain. The other samples of water in this series were collected in mid-channel from the Belfast-Heysham steamers.

It will be seen that there can be no doubt as to the vigorous absorption of ammonium compounds by *Ulva* from the polluted water, thus confirming the results previously obtained by one of us. But it should be noted that experiment No. 4 of the second series is anomalous in this respect.

Excluding No. 1 of the first series, several of the other results (Nos. 3, 4 and 6) show an effect which we had previously found during our experiments at the Pumping Station, namely an *increase* in ammoniacal nitrogen after the pure seawater had been in contact with *Ulva*. We have discussed this matter on p. 106.

(2) EXPERIMENTS ON THE ANAEROBIC FERMENTATION (PUTREFACTION) OF "ULVA" IN SEAWATER.

These experiments were made with the object of ascertaining the amount (1) of ammonia, and (2) of sulphuretted hydrogen which are produced when a known weight of *Ulva* putrefies.

(a) *Ammonia Production.*

A small flask of about 100 cc. capacity was filled with small pieces of Belfast *Ulva* packed tightly together and immersed in seawater. The flask was fitted with a delivery tube leading into a small dish containing mercury, so as to allow the gases generated to escape freely, while preventing access of air. The *Ulva* was taken in its normal wet condition and was found to contain 88·2 per cent. of water when weighed out. A separate estimation showed that this particular sample of seaweed contained when dry, 4·82 per cent. of nitrogen. The flask contained 22·6 grams of moist seaweed, equivalent to 2·67 grams of the dry material. The flask (completely filled with the seaweed and seawater up to its neck) was incubated at 90° F. from February 10th, 1910, to April 15th. At the end of this period of nine weeks, the *Ulva* was partially blackened, smelt strongly of butyric acid, and had, indeed, a most nauseating stench.

The remains of the weed and the liquor containing much colloidal matter, were removed from the flask, filtered into a 250 cc. flask and washed with distilled water until the total volume of liquid amounted to the quarter litre. A determination of the ammonia in a fraction of this, showed that the whole extract contained 0·04 grams of ammoniacal nitrogen. The total nitrogen in the whole of the original amount of *Ulva* placed in the flask was 0·13 gram. Therefore, practically one-third of this had been converted into ammonia in the given period, although the decomposition was by no means complete.

(b) *Sulphuretted Hydrogen Production.*

These experiments were designed to ascertain how *Ulva* grown in an unpolluted locality, would compare with *Ulva* grown in Belfast Lough as regards the nuisance produced by sulphides liberated from the decaying weed.

Four small flasks (of the type used for the ammonia experiment) were filled with *Ulva* from Studland Bay and four with *Ulva* from Belfast Lough. Two small wash-bottle flasks were joined in series to each of the flasks holding the *Ulva*. The first of these was left empty to catch any liquid sucked back or driven over from the other flasks; the second flask held 25 cc. of $\frac{N}{10}$ sodium arsenite solution. From one flask of each class of weed a delivery tube was led under a mercury seal to a collecting tube, so that the rate of gas production (other than hydrogen sulphide) might be observed.

All the flasks were placed in an incubator at 90° F. on November 12th, 1910.

The weight of weed taken for each experiment was either 30 or 35 grams. The Studland *Ulva* contained 87·8 per cent. of moisture, while the Belfast *Ulva* contained 90·0 per cent.

The results of these experiments are very peculiar. Of the four samples of Studland (pure water) *Ulva*, three produced a little hydrogen sulphide, and one flask a very considerable quantity.

Of the four Belfast flasks one was lost by breakage, but none of the other three produced any hydrogen sulphide. A fifth flask of Belfast *Ulva* started on December 12th had produced a little sulphide on January 13th, 1911.

The hydrogen sulphide yielded by the sample of Studland *Ulva*, which fermented so energetically, amounted to 0·107 gram. This was produced between November 12th, 1910, and January 13th, 1911, when gas was still coming off freely.

Although these experiments are very inconclusive, they show, at any rate, that *Ulva* grown in a locality where the water is unpolluted by sewage is capable of giving rise to very considerable nuisance.

14.—NOTES ON THE ANALYTICAL METHODS USED IN THE INVESTIGATIONS.

(1) *Ammoniacal, Albuminoid and Oxidised nitrogen.*—All the estimations of these were made by the methods described in the Commission's Fourth Report, Vol. 4, Part V.

Certain unimportant modifications were made to suit the particular experiments and ammonia-free water was of course used in all the estimations.

The quantities taken for analysis in the case of pure seawater were :—

For ammoniacal and albuminoid nitrogen, 500 cc.
For oxidised nitrogen, 100–200 cc.

For polluted seawaters, these quantities were reduced in accordance with the degree of pollution known or suspected.

Regarding *nitrates* in view of the possibility of the alkaline salts and organic matter affecting the determinations, the following experiments with known quantities of nitrate in seawater were made.

	Nitric Nitrogen Found.
(1) Seawater from Blackhead - -	0·007 per 100,000.
(2) Seawater from Blackhead + 0·00001 grammes Nitric N. (added as KNO_3) - - -	0·018 ,,
(3) Seawater from Blackhead + 0·0001 grammes Nitric N. (added as KNO_3) - - -	0·095 ,,
(4) Seawater from Blackhead +5 per cent. Sewage*+0·0001 grammes Nitric N. as KNO_3	0·090 ,,

The quantities of nitric nitrogen which should have been found in experiments (2), (3), and (4) are 0·017, 0·107, and 0·100 respectively.

It will be seen that the results obtained were sufficiently accurate for all practical purposes.

(2) *Dissolved Oxygen.*—Three different methods have been used, namely, the gasometric, in a modification of Adeney's apparatus, Letts and Blake's volumetric method, and Winkler's volumetric method.

(3) *Total Nitrogen in Seaweeds and Muds.*—This was estimated by Kjeldahl's method as follows. From 0·5 to 1·0 gram of the dry sample was heated with 5 cc. of sulphuric acid and 1 gram. of potassium sulphate until the mixture became colourless and the remainder of the operations carried out in the usual manner.

(4) *Sulphur and Phosphorus in Seaweeds.*—These were determined by a method devised by one of us, which resembles that of Knop and Arendt as described in Fresenius' Quantitative Analysis Part II. B.

About 5 grams. of the dried seaweed are weighed out and placed in a porcelain dish and 50–60 cc. of *fuming* nitric acid added, the dish being covered with a watch glass and of about 200 cc. capacity. The dish and contents are next heated on a water bath until all action is over and the pasty mass which forms at first has become liquid, a little more acid being added if necessary. The watch glass is then removed and the evaporation carried on until the contents of the dish are nearly dry. The dish is now removed from the water bath, again covered with the watch glass and carbonate of soda added (in solution) until the mixture is slightly alkaline. The latter is now evaporated to dryness on the water bath, and the dish heated until the mass fuses and the carbon disappears. The residue is next acidulated with nitric acid, evaporated to complete dryness to render the silica insoluble, made up to a definite volume and the phosphorus determined in an aliquot portion with ammonium molybdate and the sulphuric acid in the remainder in the usual manner.

(5) *Drying Ulva and other Seaweeds for Analysis.*—The seaweeds were washed free from sand etc. in tap water, spread out on filter paper until air-dry and then placed in a steam oven. When free from moisture the fronds were easily pulverized in a small mortar and were finally dried, at first (1909 experiments) over sulphuric acid in a desiccator for 48 hours, but later it was found more satisfactory to dry the powdered weed again in the steam oven for 24 hours.

(6) *Analysis of Muds and Sludge given in Table XLII.*—The finely powdered samples of dry mud were treated with fuming nitric acid, a little hydrochloric acid being added when fuming had ceased. No fusion with alkali was made with these samples. The iron was determined volumetrically in the acid solution and the sulphur and phosphorus as in (4) above.

February, 1911.

E. A. LETTS.
E. H. RICHARDS.

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* No nitrate in sewage and seawater mixture by brucine test. It had been kept for some days.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

APPENDIX IV.

ON THE GROWTH OF *ULVA LATISSIMA* IN EXCESSIVE QUANTITY, WITH SPECIAL REFERENCE TO THE *ULVA* NUISANCE IN BELFAST LOUGH.

BOTANICAL REPORT BY A. D. COTTON.

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THE following report deals with the botanical aspect only of the *Ulva*-question. It is divided into three parts, namely: (1) a description of the growth of *Ulva* on the sloblands of Belfast; (2) an account of various other localities investigated with a view to explaining the conditions which bring about excessive *Ulva*-growth; and (3) a general summary of the ecology of *Ulva*, a discussion on the question of its growth in excessive quantity, and the conclusion as to Belfast.

PART I.

THE GROWTH OF *ULVA* ON THE BELFAST SLOBLANDS.

INTRODUCTION.

Belfast Lough as regards its marine flora may be roughly divided into two parts: (1) the seaward portion; and (2) the inner, or enclosed portion at the southern end. The foreshore of the former is composed of a beach of rocks, stones, or sand, and is more or less open to the sea; whilst that of the latter consists largely of mud-flats which are bathed by water rendered brackish and impure by rivers and sewage discharges from the neighbourhood of Belfast. The effect upon the flora of the difference in conditions is very marked. In the seaward portion of the Lough, there is a marine vegetation such as one finds on a sea-coast, namely a large number of species, including many of the finer and beautiful red forms belonging to the order *Florideæ* (or "Red algæ"). As one approaches the inner portion of the Lough with its flat shores, many of the marine plants disappear, and the number of different kinds becomes gradually less, till at the Belfast end of the Lough the number of species present is exceedingly small. At the same time one or two species occur in the inner part of the Lough, that are not found in the seaward portion, the quiet water, flat shore with strong light, or some other factor favouring their growth.

The influence of external conditions in determining the presence of different species is a most interesting but often difficult study, as many factors have to be taken into consideration. In Belfast the most striking effect of the different surroundings in the inner Lough is the almost complete disappearance of the "Brown" and "Red" Algæ* and the remarkable increase of the "Green Algæ," especially as regards bulk. The present section of the report deals entirely with this inner portion of the Lough (*i.e.*, that part within Carrickfergus on the one side and Grey Point on the other,) and mainly with that end of it which is nearest to the city (see Map). The shores of the inner Lough consists of mud-flats or sloblands. Towards the city end the mud exposed at low-water is extensive, the sloblands being in places a mile wide on both sides. Below half-tide level the mud is soft, and in some places cannot be traversed without danger. Above half-tide level it gradually becomes firmer, and small stones and shells may be found resting on the surface. From half-tide level and below there are, especially on the County Down side, vast mussel-beds which are of great importance in connection with the *Ulva*-question, in that they afford anchorage for the plants. Banks of empty mussel-shells and other shells also occur, but these are devoid of vegetation, owing to their being constantly shifted by the tide. Near Macedon Point on the County Antrim side and Holywood on the County Down side, the shore becomes less muddy and rocks begin to occur; the appearance of the latter being correlated with a marked increase in the number of species of seaweed.

The water of the inner Lough possesses a low salinity which is to be accounted for by the inflow of the River Lagan, the Connswater and other streams that flow into it. The sewage-pollution of the Lough has been worked out very thoroughly by Professor Letts and Mr. E. H. Richards. Their investigations show that in that part of the Lough which would be inside a line drawn from Macedon Point to Holywood, the water is fouled with sewage to a degree corresponding to about 1 per cent, by volume of sewage as measured by ammoniacal nitrogen. The degree of pollution over this part of the Lough is remarkably uniform except in the immediate neighbourhood of sewage discharges. Another factor to be noted is the absence of strong currents and breakers, though in stormy weather waves of considerable size may develop. The water on the mud-flats may therefore in a general way be considered to be smooth.

ULVA LATISSIMA AND THE ULVA-NUISANCE.

Nomenclature of Ulva and other algæ.—Modern botanists are agreed that *Ulva latissima* as generally understood is a variety of *Ulva Lactuca*, L. The varieties of the latter plant are very numerous, and opinions differ considerably as to the way in which they should be classified. In systematic algology it is now customary to use the designation *Ulva Lactuca*, L. var. *latissima*, DC., but as the name *Ulva latissima* (which was in use until recently in scientific works, and is known to all) has already been adopted by the Commission, it is used throughout in this report.

With regard to the various forms of *Ulva* that have been met with, the writer agrees with Batters and other botanists that all the British plants rank as forms or varieties of a single species, *i.e.*, of *Ulva Lactuca*, L.* These forms, which are without doubt very largely the result of external conditions, are often not sharply defined, but can be connected with each other by a perfect series of transitions. Some twelve or more forms have been distinguished by continental writers, who have given them names, but it has not been thought advisable to enter into this aspect of the question, indeed to attempt to do so would involve several seasons' study.

Ulva is therefore here regarded as a single species liable to variation, and the name *U. latissima* is applied not merely to the free-floating form of quiet creeks and bays, but also to the mussel-attached form of estuaries.

Of the green algæ which form the characteristic vegetation of the Belfast sloblands, *Ulva latissima* and various forms of *Enteromorpha intestinalis* are the most abundant. The growth of *Ulva* is remarkable, wide stretches of mud-flats many hundreds of acres in extent being covered with a green sward of almost pure *Ulva*. In addition to *Ulva latissima* and *Enteromorpha intestinalis* two species of *Monostroma* are also present in quantity (at all events in spring and early summer); and these bear so strong a resemblance to *Ulva* that to the untrained eye they are almost always confused with that plant. A fourth growth that must be mentioned in connection with the *Ulva*-nuisance is that known by such popular names as "May Fog," "Flannel Weed," etc. The growth in question forms a flannelly or ropey mass, and usually consists of more than one species. In Belfast as at other places the smell arising from the decay of "May Fog" is said to be more objectionable than that from *Ulva*. The two species of *Monostroma* and the "May Fog" weeds are discussed under the heading "General flora of the sloblands" (p. 124).

Extent.—The *Ulva*-growth on the Belfast sloblands occurs mainly on the County Down shore. In former years there was a very considerable growth on the County Antrim side, but during 1909 and 1910 the growth has been insignificant, and any nuisance that may arise there is probably entirely due to weed washed ashore from the other side. On the County Down side the *Ulva*-beds occur between the Musgrave Channel and Cultra, and the greatest development is found between the Connswater bank and the Kinnegar. Between Musgrave Channel and Cultra there exist some 2,400 acres of slobland (see Map).

The *Ulva*-beds are found in a general way between half-tide level and low-water mark, but where pools, streams, or areas of shallow water occur, *Ulva* is found much higher up. On the County Down shore, the Silver Stream and the Tillysburn afford the largest and most vigorous fronds of *Ulva* that have been noted. *Ulva* in such positions is never exposed to the air but always submerged. By far the largest part of the *Ulva*-growth occurs, however, on mussel-beds that are left dry at low-water. In this

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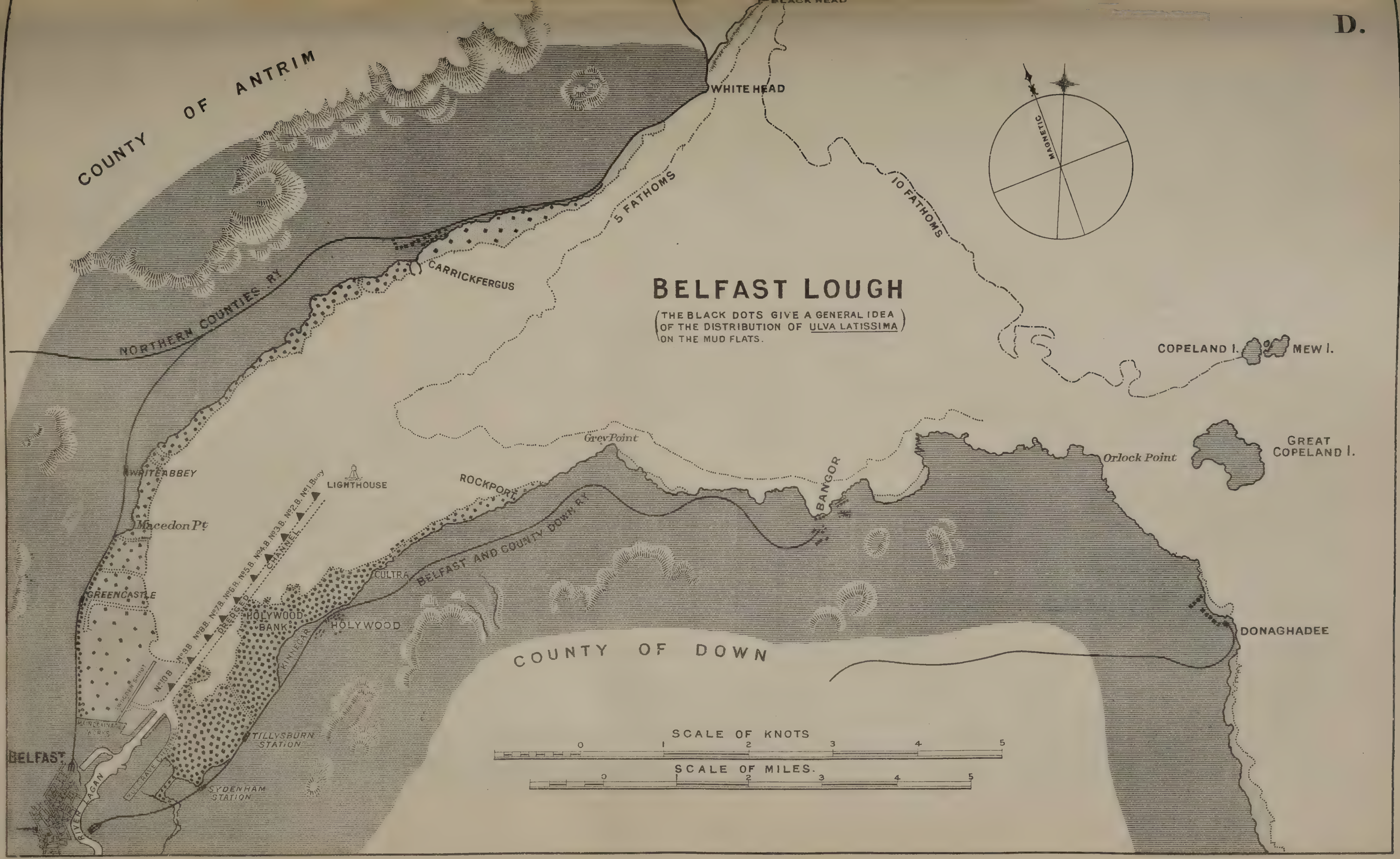
* It so happens that in Algæ, the colour of the plant forms a natural method of classification. Algæ possessing red pigment compose the group *Rhodophyceæ*, those possessing brown pigment constitute the *Phæophyceæ*, whilst those that contain only green pigment form the *Chlorophyceæ*. The "Green Weeds" in common with many "Brown Weeds" are well-known to prefer strong light; whilst the "Red Weeds" as a class are shade-loving plants, inhabiting deep water or shady pools. Many of the latter are much discoloured by the light in summer even in the sub-littoral region.

* It should be mentioned that the *Ulva Lactuca* figured in Harvey's well-known "Phycologia Britannica" (pl. 243), is an entirely different plant, and is not now regarded as an *Ulva*, but as a species of *Monostroma*, namely *M. Grevillei*. *See* p. 124 of this report.

D.



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Malby & Sons, Lith.

position it is more likely to be affected by wave action, and the individual fronds are not so large. The growth here, though short, is very dense.

Reproduction.—The normal method of reproduction in *Ulva* is by spores. The spores are formed in the ordinary frond, but the portion becoming fertile is usually confined to the apex and margin. The spores are exceedingly minute and several are formed in each cell. A very large number may therefore be produced by a single plant (see Plate, figs. 9–12). When the spores have been discharged from the cells the fertile area remains as a dirty-white membrane around the frond (Plate, fig. 1); the empty cells retaining their form for a short time, and the pore in each, through which the spores were discharged, being plainly visible under the microscope (Plate, fig. 11). Later on the white margin falls away. Spore-formation may be repeated several times in the life of a plant. As far as has been seen at present this method of reproduction does not take place to any very great extent on the sloblands. Fruiting fronds have been noted on the County Antrim side on small plants attached to stones, and a few on similar plants on the County Down side, and doubtless many others could be found if searched for. There is no doubt that the spores produced in this way would be amply sufficient to stock the entire Lough. Many small sporelings may, if carefully looked for, be found on stones, and on other algæ as epiphytes. These as a rule do not attain a large size, but they show that spores are liberated and that they germinate.

The bulk of the *Ulva* occurring on the sloblands appears to increase entirely by a vegetative method. As explained below mussels play a very important part in the growth of *Ulva*, and when the plants are attached to mussels they appear to be more or less perennial. In summer the tops of the fronds are torn off by wave-action and the old fronds throw out new growth very readily; and these plants although much reduced by autumn gales may live through the winter and produce large plants the following spring. An increase in the actual number of plants also probably takes place by vegetative methods. Firstly, when loose pieces of young fronds become caught in the mud or on mussel banks, certain fragments are almost certain to be fastened upon by mussel byssus, and being capable of growing, they can give rise to a new individual; secondly, an increase of plants may occur by a process similar to layering. The mussels attach themselves to a young active frond lying horizontally and fix it to themselves thus forming a new centre of growth. In the event of the parent plant dying, the young plant will probably survive.

Attachment.—A very marked feature of the *Ulva*-growth on the Belfast sloblands is the connection of the plant with the mussel-beds. On an ordinary rocky shore *Ulva* is found attached to rocks or other algæ, but on the sloblands such firm anchorage is wanting, and its place is supplied by the extensive banks of mussels. On examination of the mussel beds it is at once evident that the *Ulva* is not attached to the mussels by its basal disk, but that it is held down by the byssus threads excreted by the mussels. In this way the plants have a very firm attachment, as the threads are not only fastened in great numbers to the base of the frond, but odd threads are thrown out on to the upper and expanded parts also. The presence of the mussels therefore is of the greatest importance to *Ulva*.

Several plots on the sloblands were cleared of mussels by the officers of the Commission and the effect of the clearing was most marked, the plots remaining destitute of *Ulva* for many months. So intimate indeed is the connection of the *Ulva* growth at Belfast with the presence of mussels, that it is not going too far to say that under the present conditions if the latter were removed, the *Ulva*-growth would practically cease to exist. Dr. Letts moreover has made the interesting suggestion that there may be a biological connection between the *Ulva* and the excretions of the mussels. This theory however, requires careful investigation.

The luxuriant growth of *Ulva* in streams referred to above, was also found to be attached to mussels, and, with the exception of young plants that may be found here and there on stones, the entire growth from the Connswater bank to the Kinnegar may be said to be mussel-attached. At Holywood, rocks begin to appear, and *Ulva* is found fixed by its own basal disk. The growth is not excessive, and many other species occur here for the first time.

Growth.—Under the conditions of Belfast Lough *Ulva* grows more or less throughout the whole year. In the autumn much of the growth is detached by gales and washed ashore, but, though the banks are left comparatively bare, a walk over the sloblands shows a very large amount of healthy *Ulva* still present. Except in severe weather it is probable that slow growth takes place all through the winter. In the month of April a decided greening of the banks is noticeable which increases with the advent of warm weather. In June and July the growth is exceedingly rapid and the *Ulva* plants appear to be at the height of their vigour. In artificial cultures also, growth is very rapid at this time of the year. If the season were very hot and dry it is probable that a decrease in vigour would result, which would be followed by another season of activity in the autumn. The result of the rapid growth in summer is the production of fronds of great size. Portions of these are continually being detached and washed ashore; but this only provides further space for the plants which continue to grow, and thus the sloblands become covered with an enormous mass of vegetation.

Detachment and nuisance.—As long as the *Ulva*-plants are attached to the substratum and continue to grow they are quite unobjectionable; indeed, as is shown in Dr. Letts' previous report, they actually benefit the Lough by oxygenating the water. It is from the loose decaying fronds that the nuisance arises. Though detachment by wave-action takes place more or less throughout the year, the greatest quantity of loose weed is to be found in late summer and autumn. The weed often remains in loose masses in pools or depressions on the mud-banks, in which case it is shifted by every tide. A very large amount is however washed ashore and a bank of decaying weed thus accumulates. After a storm enormous masses may drift in, and in one day a bank 2 feet high may be formed. Such banks may extend for 2 or 3 miles along the coast. The loose weed is under certain conditions taken out by the tide and distributed over the foreshore, but often only to return again after a few days. Weed deposited under such conditions speedily decays especially in hot weather, and the putrefaction of this mass of vegetable matter gives rise to a serious nuisance. During decay sulphuretted hydrogen is given off, and it is the liberation of this gas that renders the stench so objectionable. That sulphuretted hydrogen is sometimes evolved in great quantity is shown by the fact that the white paint of boats and houses has been known to turn black in a single night, and that paper moistened with lead acetate solution held near a seaweed deposit blackens in a few minutes. Inhaling the gas produces headache and nausea, and it is not surprising that the inhabitants complain, as in warm still weather, when the gas is not dispersed by the wind, the stench along the shore is almost intolerable.* The composition of the *Ulva*-fronds and the chemical changes that take place in their decay have been carefully investigated by Professor Letts. He finds that it is probable that at least two species of bacteria are concerned. The products of the fermentation induced by the first micro-organism are fatty acids, carbonic anhydride, and hydrogen; and it is believed that this organism attacks the albuminoids of the seaweed. The fermenting *Ulva* is later attacked by another species with the subsequent production of ferrous sulphide and sulphuretted hydrogen. These sulphur compounds are probably produced from the sulphates of the sea-water and not from the albuminoids of the alga.

Formation of mud.—It is generally believed that most, if not all, of the mud in the Lough, is due to the deposition of solid matter brought down by rivers and sewage outfalls. Whilst it is true that the sewage solids have been steadily accumulating in the bed of the Lough, it is now known that a very considerable quantity of the mud is formed by the decay of the *Ulva* itself. This can readily be observed by examining the *Ulva*-mud, and it may be especially well seen in certain streams which drain the sloblands. The streams cut for themselves a bed, and thus expose a section of the mud which shows successive layers of *Ulva*-fronds in various stages of decomposition. On examining the lower layers of *Ulva* it will be found that they are quite black and brittle and that they pass imperceptibly into the black sooty mud below. Thin layers of fine solids from other sources are doubtless deposited between the *Ulva*-fronds, but at the same time it is obvious that the mass of *Ulva* that decays on the lower parts of the sloblands is largely responsible for the formation of the black ill-smelling mud that exists there.

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* Since the year 1890 several public inquiries have been held, and the matter has given rise to litigation.

On many beaches where seaweeds accumulate and decay, a black sand and sandy-mud is found, and this also is to be attributed to the decay of vegetable matter. In this connection reference may be made to Strangford Lough, where in certain parts a foul black mud exists, fully as bad as that of Belfast. The mud in this locality appears to be exclusively formed by the decay of *Zostera*, *Enteromorpha* and "May Fog."

The black colour of the sand or mud is due to the presence of sulphide of iron. The latter is derived from the sulphuretted hydrogen liberated from the decaying weeds, which in the absence of air combines with the iron present in the sand or plant-remains. As long as air is excluded the mud remains black and unoxidised; but on exposure to the atmosphere the reddish-brown ferric oxide is produced. When weed decays in thin layers, or in the presence of air, the sulphuretted hydrogen liberated is at once oxidised to water and sulphur.

General Flora of the Sloblands.

Before discussing the problems connected with the *Ulva*-nuisance at Belfast a few notes concerning the other species of algæ that occur may be useful.

1. *Monostroma.*—Two species of *Monostroma* should be noted as they bear a strong resemblance to *Ulva* and are very likely to be confused with it. The frond in the genus *Monostroma* consists of a thin flat membrane as in *Ulva*, but it differs essentially in being composed of a single layer of cells instead of two. A small species, *M. Grevillei*, Wittr., is very common on the Belfast sloblands. It grows attached to stones and shells, and is at first saccate, but sooner or later the frond ruptures and after further growth several distinct segments may be distinguished. It often remains quite small—1–3 inches, but occasionally larger specimens—up to a foot long—are found. A few specimens were noted at Belfast in December 1909; and in April and May, 1910, it was exceedingly abundant on the County Down side, especially about half-tide level. In the end of July and in August it had largely disappeared. It probably only occurs in quantity in spring, and it's small delicate fronds would contribute only a very insignificant fraction to the mass of decaying seaweed. On account of its similarity to young plants of *Ulva* its presence in quantity in the spring, might give rise to needless alarm unless its identity were known, and it is for this reason that the plant is here referred to. On the shore it may be distinguished at sight by its small size, pale colour and exceedingly thin frond, which is saccate in the young stage. In doubtful cases microscopic sections showing the single layer of cells will at once settle the question.

The other species of *Monostroma* occurring on the sloblands is *M. fuscum.* This bears an even more striking resemblance to *Ulva* than does *M. Grevillei*, it being practically indistinguishable to the naked eye. In May 1910 it was found in fair quantity in areas of shallow water at half-tide level on the County Down shore. The exact proportion of *M. fuscum* present, and the periods of year at which it is found, have not been ascertained. It is, however, a comparatively rare plant and it is not likely that it plays any material part in the *Ulva*-nuisance. It is distinguished from *Ulva* by its one-layered frond, the cells of which contain but one or two chromatophores, and by its brownish colour when dry. It also usually stains the paper black on which it is mounted.

2. *Enteromorpha.*—Next to *Ulva* by far the most conspicuous vegetation on the sloblands is that of *Enteromorpha.* This gerus is exceedingly difficult to classify satisfactorily, and when it occurs under rather peculiar conditions such as mud-flats, the growth is often coarse or abnormally large and the problem becomes even more difficult. Early in the last century it was customary to recognise a large number of species, but recently there has been a tendency to regard the so-called species as merely forms or varieties of a few very variable species. This is especially the case with such plants as *E. compressa*, *E. complanata*, *E. Linza*(*parte*), all of which are now usually regarded as forms of *E. intestinalis*, Link. *E. intestinalis* is the common species on the sloblands, and, as far as that locality is concerned, the modern view certainly appears correct, as the most perfect sequence of forms can often be traced between small, simple, tubular plants, and large flat forms with various degrees of branching. The name is therefore here used in a wide sense, and includes both the inflated and the ribbon-like forms. To accurately describe all the forms growing in the Lough would require at least one entire season's study; this has not been possible, nor, indeed, is it necessary for the present purpose.

E. intestinalis is a plant that occurs in fresh water as well as salt, and in a general way its growth in abundance on the seashore indicates brackish conditions or the presence of a stream of fresh water entering the sea. In Belfast Lough this is very apparent, especially on the Antrim side, where, immediately below every fresh-water outfall, there is a delta-like mass of almost pure *Enteromorpha.* Near the outfall the fronds are tubular, further down the shore they are flattened. Salt water and flattening appear therefore to be connected, but this is not always the case, and many puzzling exceptions may be found. Besides these masses of *Enteromorpha* the plant occurs in a scattered manner all over the sloblands from low-water line to that of high water. It is usually attached to small stones and shells, and thus fills in areas not occupied with *Ulva.* In spite of the abundance of the plant and its conspicuousness on the mud-flats, no bulk of loose *Enteromorpha* fronds have been noted; it occurs, however, fairly plentifully amongst the loose *Ulva*, and is in part responsible for the mass of decaying weed on the shore.

3. "*May Fog*" *or* "*Flannel Weed.*"—On the upper part of the sloblands there occurs a growth often collected into masses or rope-like strands which is known locally as "May Fog"; at Southampton it is termed "Flannel Weed," and at Weymouth "Blanket Weed." The growths consist of one or more species, and the popular names are found to include various matted growths of this nature. Both in Belfast Lough and in Strangford Lough the growth consists of an *Enteromorpha* and a *Cladophora.* The species of *Cladophora* like those of *Enteromorpha* are difficult to classify, but there seems no doubt that the *Cladophora* constituent of "May Fog" at Belfast is a loosely-branched attenuated form of *C. sericea*, *Kütz.*; whilst the *Enteromorpha* constituent is a very long and often much branched form of *E. prolifera*, J. Ag. Both at Belfast and at Southampton "May Fog" has the reputation of producing a most pungent smell on decay, but whether it is the *Enteromorpha* or the *Cladophora* or the mixture of both that is responsible is not known. Under somewhat artificial conditions the smell of decaying *E. prolifera* was found to be very offensive. Both these weeds also occur separately on the sloblands, the *Enteromorpha* especially, and at times it reaches nearly up to high-water level. *C. sericea*, which is less frequently met with, is usually found in the damper regions about half-tide level. At Weymouth and Southampton the composition of "May Fog" is somewhat different, a large proportion of the growth consisting of *E. clathraia*, J. Ag. At Weymouth the *Cladophora* constituent is mainly *C. gracilis*, Kütz., whereas at Southampton *C sericea* is the more common species.

The above-mentioned plants are the only ones directly connected with the nuisance at Belfast, but for the sake of completeness a list is given of other seaweeds that have frequently been met with on the sloblands within Holywood and Macedon Point.

Very common on sloblands, attached to stones and shells.	*Ectocarpus littoralis, Lyngb.*	
	Phyllitis fascia, Kütz.	
	Porphyra umbilicalis, Kütz.	
	Dumontia filiformis, Grev.	
Less common -	*Fucus vesiculosus, L.*	
	Ceramium rubrum, Ag.	
	Polysiphonia nigrescens, Grev.	
On the rocks at Macedon Point.	*Fucus vesiculosus, L.*	Brown Algæ.
	Fucus serratus, L.	
	Ascophyllum nodosum,LeJol.	
	Cladostephus spongiosus, Ag.	
	Ectocarpus littoralis, Lyngb.	
	Porphyra umbilicalis, Kütz.	Red Algæ.
	Chondrus crispus, Stackh.	
	Gelidium pusillum, Le Jol.	
	Gigartina mamillos, J. Ag.	
	Polysiphonia nigresens, Grev.	
	Polysiphonia fastigiata, Grev.	
	Ceramium Deslongchampii, Chauv.	
	Ceramium rubrum, Ag.	
	Dumontia filiformis, Grev.	
	Hildenbrandtia prototypus Nardo.	

THE CONDITIONS INDUCING EXCESSIVE GROWTH.

The three principal facts established with regard to the *Ulva*-nuisance are: (1) That large areas exist on the Belfast sloblands covered with *Ulva latissima*; (2) that the growth of *Ulva* on the sloblands is exceedingly luxuriant, and in summer takes place very rapidly; and (3) that it is the decay of this weed that causes the nuisance complained of. The central point, therefore, in the *Ulva* inquiry is to determine the factor or factors which induce such abundant and excessive growth.

The presence of sewage pollution has for many years been regarded as playing the most important part in connection with *Ulva*, and the question had arisen whether it would not be possible to prevent the growth by purifying the Belfast sewage effluent.

The evidence brought forward in favour of the excessive growth being due to sewage pollution is very strong, and may be grouped together under four heads as follows:—

(a) *Distribution of Ulva on the Coast.*—The frequent abundance of *Ulva* at the mouths of large rivers both in Britain and on the Continent is well-known; small harbours also, where the water is sometimes very foul, often possess a vigorous growth. Its abundance in certain rivers and estuaries visited by Professor Letts and Dr. Adeney in 1904 confirmed the view that sewage favoured its growth, as did also its absence from other localities where pollution was practically absent. In Dublin Bay, moreover, which at that date showed a well-marked polluted and unpolluted region, the weed was confined to the polluted area.

(b) *Composition of the Ulva-fronds and the Assimilation of Nitrogen Compounds.*—A series of experiments carried out in 1904 and 1905 by Dr. Letts showed an extraordinary power on the part of *Ulva* of absorbing ammonia and nitrates from the surrounding water; and at the same time analyses of the fronds showed the presence of a very high proportion of nitrogen. The proportion of nitrogen appeared to correspond with the amount of pollution present. These facts doubtless explain how it is *Ulva* can flourish in polluted water, and are of great interest in connection with the purification of water by marine vegetation. The ammonia present in the water is thought to act as a fertilizer and to result in the production of a large amount of rank growth.

(c) *Artificial Cultures.*—During the year 1909 a set of cultural experiments were commenced at Belfast by Professor Letts, and from the autumn of 1909 to the end of the 1910 season the experiments were continued on a much larger scale in conjunction with Mr. Richards. Some of the most important of these experiments consisted in growing *Ulva* in various solutions and recording the increase in size and weight. The experiments show that the growth of *Ulva* in mixtures of seawater and sewage, and in seawater and percolating filter effluent is greatly stimulated by sewage and sewage pollution. A full account of these experiments is given in the report by Professor Letts and Mr. Richards. Plants under artificial conditions require careful treatment, and caution is needed in deducing results, as the possible sources of error in the experiment are not always apparent. It is not surprising, therefore, that a few contradictory results have been obtained. It must be borne in mind that the metabolism of *Ulva* varies greatly at different periods of the year, and that little more than one season has elapsed since this method of investigation was begun. Being pioneer-work the results of another season would be of much more value.

(d) *History of the Nuisance at Belfast.*—In the opinion of most of the residents at Belfast there was no nuisance due to rotting seaweed till after the middle of last century. Formerly the Belfast sewage was discharged into the river Lagan the waters of which were exceedingly foul and turbid, the Lough, however, remained clean and clear up till some sixty years ago. Professor Letts has the authority of Sir Robert Paterson for saying that the flora of the upper reaches consisted mainly of *Zosiera*. *Ulva* and *Enteromorpha* were reported to be practically absent. As the population increased *Zostera* gradually gave place to a growth of green seaweed, which on decay gave rise to a nuisance in warm weather. The new main drainage system which was started in 1889 instead of preventing the nuisance apparently only made matters worse. It should be noted that there is some difference of opinion as to the absence of *Ulva* during the middle of the past century and that certain of the residents do not agree that the nuisance is of recent origin.

The four points above alluded to, *viz.*, the distribution of *Ulva*, its avidity for nitrogen compounds, its growth in artificial cultures, and the history of the nuisance at Belfast constitute the principal evidence for the pollution theory. As the acceptance of this view is a matter of great consequence for Belfast, it is necessary that the proof be firmly established. It is obvious, however, that even if the arguments do not prove conclusively that sewage is the primary cause of the excessive growth, they show that it is intimately connected with it, and at the same time emphasize the important part that green weeds play in the economy of nature.

In order to place the theory beyond dispute it was essential to ascertain the relative importance of the other factors present at Belfast, especially the influence of brackish water, the tranquil conditions, the flat shore with strong light, and the presence of mussels. Further, it was not at all certain that localities did not exist on the British coast where *Ulva* occurred in quantity in the absence of sewage pollution. In order to answer these questions with certainty it is necessary not only to have a general knowledge of the growth of *Ulva*, but to make a thorough study of its occurrence in localities offering considerable variety of external conditions. Though the weed is generally regarded as common on all our coasts, there is practically no accurate information as to its relative abundance, nor any detailed account of its ecology. For this reason Professor Letts and the writer undertook a short survey of the Antrim coast in May, 1910. The tour was instructive and suggestive, but as usual in biological investigations many new questions were raised. In addition to this tour the writer paid a special visit to the neighbourhood of Swanage, in June, to examine *Ulva* in that locality, an examination which was repeated by a visit with the Commissioners in September, and again in November when he was accompanied by Professor Letts and Mr. Richards. A few observations were also made on Clare Island and Clew Bay (County Mayo) in June and October.

It should be emphasized that biological problems of this nature are not so readily solved as might be supposed. Though it is easy to record facts, caution is necessary in drawing conclusions, all the factors having to be taken into consideration. The conclusions, therefore, need testing, and on this account considerable time is required. Since the present observations cover less than a season, and the time available has been limited, it is not surprising, that several points remain unsettled.

Several very important facts have, however, been clearly established, and these are dealt with in Part ii. in connection with the various localities under investigation. In the final summary (Part iii.) these results are brought together.

SUMMARY

Large areas of the Belfast sloblands are covered with a growth of the seaweed *Ulva latissima*. The plant grows very luxuriantly in the summer months, but sooner or later the fronds are detached and are at times washed ashore in great quantity. On decay the detached weed gives rise to a serious nuisance owing to the liberation of sulphuretted hydrogen.

The Ulva-growth on the sloblands is found for the most part between half-tide level and low-water mark, but where pools or streams exist *Ulva* extends much higher up. By far the greater part of the growth occurs on mussel-beds; the tough threads or "byssus" of the mussels attaching themselves to the *Ulva*-fronds. The latter are thus firmly fixed and can resist considerable wave-action. *Ulva* under these conditions does not die down annually, but appears to exist throughout the winter as a short growth attached to mussels. The greater part of the fronds are torn off by autumn gales, but the basal part that remains *in situ* shoots out again in spring. Reproduction thus appears to take place largely by a vegetative method and not by spores. Extended observations on this point and also on the method of wintering are desirable.

The growth in summer is rapid and luxuriant, and as the area covered by the weed is very extensive the amount of *Ulva* that exists in summer is extremely large. Consequently with certain winds excessive quantities are washed ashore, and the nuisance that arises on decay is at times very serious. In addition to the offensive smell emitted the decaying seaweed produces a very foul black mud which contributes largely to the formation of the mud banks.

Several other weeds also occur in profusion on the sloblands, but compared with *Ulva* the growth of these weeds is insignificant. The nuisance that occurs in Belfast is solely due to rotting seaweed and principally, if not entirely, to *Ulva latissima.*

PART II.

THE GROWTH OF *ULVA* IN LOCALITIES OTHER THAN BELFAST.

A.—County Antrim Trip, May, 1910.

The object of this trip was to investigate the amount of *Ulva* that occurs in various types of localities, and especially in those afforded by marine loughs and mouths of rivers. The tour was arranged by Professor Letts, who suggested an examination of the immediate neighbourhood, selecting Strangford Lough and Larne Lough, and the coast-line of County Antrim. The two loughs chosen were excellent for comparison with that of Belfast, both possessing but a small amount of sewage-pollution. The Antrim coast with seven small rivers also appeared particularly suitable.

With regard to the tour, it must be remembered that investigations can only take place at low-water, and therefore when a considerable area has to be covered in a short time, such a tour constitutes a survey rather than a detailed examination. The weather experienced was exceedingly wet and stormy which further curtailed the examination of certain localities. In addition it was found to be somewhat early in the season for the purpose.

An account of the tour is given below, and also a summary of results.

Strangford Lough.—This lough resembles Belfast Lough in extent of area, in the absence of rough water, and in the mud-banks exposed at low-water. It differs in possessing no large rivers polluted by sewage, and, as far as was seen, in the absence of mussel-beds. At one end, however, a small river from Newtownards discharges itself into the Lough, and as this river is polluted, that part of the Lough must be regarded as contaminated.

In most of the localities examined very little *Ulva* was present. The polluted area showed no more than the unpolluted. In one spot a luxuriant crop was noted on rocks, a fact which proved that the character of the water was not unsuitable. Other causes must therefore be sought to explain its scarcity. Of these the absence of a firm substratum is almost certainly the most important; at all events the most striking difference between the two Loughs is the absence of mussels at Strangford.

The luxuriant crop above referred to was found in a part of the Lough where the conditions were more marine, and removed from the likelihood of sewage pollution. The growth occurred on recently moved rocks, and showed that, given a firm substratum uncolonized by other algæ, *Ulva* could rapidly gain a footing and could grow vigorously. In course of time, *Fucus* would doubtless appear on the rocks, and *Ulva* would probably be more or less crowded out by the stronger growth and dense shade of the latter. A sample of water was taken from this locality. On examination it was found not to be pure but to contain a certain amount of ammoniacal and albuminoid nitrogen. The impurity was similar in character to that of sewage, but as sewage-fouling was improbable, it seemed likely that the pollution found was due to rotting seaweed or to contamination from the shore.

Another point noted in Strangford Lough was the presence of a very foul black mud derived entirely from the decay of marine vegetation (chiefly *Zostera* and *Enteromorpha*), and giving off sulphuretted hydrogen when stirred. In hot weather this mud must be very offensive. The fact that in the absence of sewage, a luxuriant vegetation other than *Ulva* may exist, and on decay produce a foul-smelling mud, is not without importance in connection with Belfast.

A careful study of the distribution of *Ulva* and of the general vegetation of Strangford Lough would be most interesting, and if continued throughout an entire season, with details as to substratum, currents, analyses of water, etc., would yield results of economic as well as scientific importance. The three points observed or confirmed during the one-day survey of the locality were:—The importance of anchorage, the presence of a pollution not caused by sewage, and the formation of a foul mud due to the decay of *Zostera* and *Enteromorpha*.

Larne Lough.—Larne Lough is another example of a marine lough providing quiet water. Large sand-banks are exposed at low tide and in places (*e.g.*, near the town of Larne) there is much soft mud. The pollution of the Lough must be considerably less than that of Belfast, as Larne sewage is now discharged outside the harbour; though doubtless in years gone by much drainage found its way into the Lough. As far as was observed no mussel beds were present.

A fair quantity of *Ulva* was found attached to rocks and stems of *Fucus* near low-water mark at Curran Point. The plants here were strong and vigorous, and the conditions were evidently favourable for growth. On the ebb tide there would be a fairly strong current due to the draining of the entire Lough. Any pollution from the mud of Larne Bay would probably pass close to this point.

On the sand and mud-banks the principle vegetation is *Zostera*, but *Ulva* is fairly plentiful in places though always mixed with other species (*e.g.*, *E. intestinalis* and *E. prolifera*). The absence of a firm anchorage renders the sand and mud more favourable for the growth of *Zostera* than that of *Ulva*. Most of the *Ulva* found was attached to stones.

Rivers of Glenariff, Cushendall and Cushendun.—One day was spent examining these rivers. In each case the pollution expected was slight. The object of the examination was to ascertain whether, in the absence of sewage-pollution, the mixture of fresh and salt water at the mouths of rivers encouraged the growth of *Ulva*, and to compare the flora of these localities with that of Belfast Lough. On examination, however, the rivers, though supplying the conditions referred to, were found to present other features which complicated the problem, and rendered a comparison with large rivers impossible. All three rivers were small, and consequently only a very small area where the desired conditions can exist is presented near the mouth.

a. The Glenariff river flows out at Red Bay amongst rocks and sand. A small amount of mud bank is exposed near the mouth at low water. No *Ulva* was found on the mud-banks, but on the rocks at the mouth a few young plants were collected. *E. intestinalis* in various forms was very abundant.

With regard to the absence of *Ulva* here, it should be noted that the banks could hardly be considered suitable for the plant. There was no firm anchorage in the mud save a few rocks and stones, and these were mostly too near high water line. The lack of *Ulva* on the rocks at the mouth which appeared suitable for its growth was thought at the time difficult to explain, but on looking back it seems possible that the abundance of *Enteromorpha intestinalis* indicated the presence of too great an amount of fresh water. Whether the fresh water strikes the rocks from the river at certain phases of the tide, or whether only after heavy rains, was not determined. Such points as these which are not unimportant, show the need of a detailed study of each locality.

b. The Cushendall river, a fairly large and rapid stream, flows out on to a beach of rocks and sand. No mud banks were seen. Scarcely any *Ulva* was found. As far as could be seen this locality did not appear at all suitable for the plant.

c. At Cushendun a small amount of mud is exposed near the mouth of the river at low-water. Pollution is probably very slight. No *Ulva* occurred on the mud-banks, but a fair amount was found growing in rock-pools on the shore to the right of the bay. A considerable quantity also was washed ashore, but it was not possible to ascertain from whence this had drifted. Amongst it were numerous fronds of the hardly distinguishable *Monostroma fuscum*.

In none of the three localities visited on this day was any quantity of *Ulva* found. On the mud-banks it was entirely absent. In examining the conditions presented by these rivers, in addition to the importance of the substratum as noted previously, the nature of the current and character of the water have to be taken into consideration. Judging from the presence of *Fucus ceranoides* at Glenariff and Cushendum, a considerable amount of fresh water is present. Another species, *Ulothrix speciosa*, also noted in abundance at Cushendum, is in the experience of the writer, characteristic of stones in the mouths of fresh water streams which are flooded for a part of the day by salt water.

To obtain an accurate knowledge of the changes that occur in the water, at the mouths of small rivers during the ebb and flow of the tide, detailed observations and analyses would be necessary. These have not been made. In the absence of such, however, it is reasonable to assume that there is at the lower levels of the banks a regular alternation of fresh and brackish water; and, that after heavy rains the banks of the river may be flooded with fresh-water to a much higher level than is usually the case. These changes are not so marked in large rivers and estuaries and would be hardly perceptible on the Belfast sloblands. It is well-known that certain algæ can stand the change from salt to fresh water with impunity (*e.g.*, those that grow on the bottoms of steamers plying daily from one type of water to the other); others, on the other hand, are very sensitive to such changes. As far as the present observations extend, *Ulva* is not able to grow in very brackish water, nor is it found in places that are occasionally flooded with fresh-water. On the other hand, unlike some seaweeds, it is able to stand a considerable amount of rain without injury. In the mouths of none of the small rivers hitherto examined, whether polluted or not, has *Ulva* been found, except in very small quantity, and it is probable that lack of salinity at certain phases of the tides is intimately connected with this fact.

The writer cannot help thinking that for some obscure reason the mouths of the rivers examined on this trip were not suitable for the growth of *Ulva*. The absence of the weed must not, therefore, without further evidence, be attributed to the absence of pollution. The nature of the banks was largely responsible for the scarcity of *Ulva*, and probably also the strength of the current and the nature of the stream.

Few if any of our smaller rivers that end abruptly on an open coast would be favourable for the investigation of the effect of brackish water on the growth of *Ulva*. The more suitable localities for this work would be an indented coast, where fresh water streams run into loughs or narrow arms of the sea. The transition from one set of conditions to the other would here be less sudden, and more suitable for the growth of brackish-water plants.

Ballycastle, Bushfoot, and Bann.—The mouths of each of these rivers was briefly examined, but very little *Ulva* was found. For reasons given above this is regarded as of little importance in connection with the pollution question. It is possible that if a detailed examination had been made more *Ulva* would have been discovered, as the rivers were apparently in flood and the state of the tides was not particularly suitable. The examination, however, would not have been worth the time and labour necessary, as more instructive localities remained to be considered.

Giants' Causeway.—In some respects the brief inspection of the flora of the Giants' Causeway was the most interesting investigated on the trip. The spot was selected in order to examine the growth of *Ulva* in a locality far removed from rivers and sewage pollution and in one which should present a typical marine flora. The character of the coast is too well known to require description, but it may be mentioned that though the shore is an exposed one and the water fully saline, the force of the waves in the bays is much broken by rocks and that many protected pools and areas of shallow water occur. Fresh water also oozes from the cliffs and thus the pools near high-water line may become brackish.

The first two amphitheatres after passing the Causeway hotels were examined. In the first *Ulva* is generally distributed in the pools at about half-tide level, but it is not abundant. The plants were mostly young and of a short, oblong or lanceolate form. In the second amphitheatre *Ulva* was abundant in the pools and streams, chiefly the short lanceolate form noted above. In one spot, where a stream of brackish water ran down from the bay and through a bank of decaying seaweed, *Ulva* was extra large and vigorous. The plants in both these bays were young and a few weeks later the amount of growth would doubtless have been much more extensive. Four other algæ occurred abundantly amongst the *Ulva*, viz.: *Enteromorpha intestinalis, Cladophora sericea, Dumontia filiformis*, and *Laurencia caespitosa*, the first three being present also on the sloblands. In addition there were the usual marine species characteristic of such bays.

Though no sewage pollution was expected in this neighbourhood it was afterwards discovered that there are public lavoratories in the second bay, the discharge from which empties itself into the sea at about low-water level of the lowest spring tides. This bay is therefore largely polluted in summer and the effect of it may be felt to a certain extent throughout the year. In both bays a fair amount of rotting weed also occurred on the shore. Opportunity therefore was afforded of investigating the point noted at Strangford Lough and suspected for some time previously by Dr. Letts that the products of decaying seaweed foul the water in a similar way to that of sewage. A sample of water was collected from the rock-pools of the first bay for analysis. It was found by the ammonia test to be distinctly polluted containing ·005 free ammonia, and ·043 albuminoid ammonia per 100,000 parts.

In the light of these facts the growth of *Ulva* in these two bays is of special interest. In the first bay where there is distinct natural pollution there was in the beginning of May a fair amount of *Ulva;* whilst in the second, where in summer there is artificial as well as natural pollution, the growth is much greater. In both, later in the season it would probably be much more extensive. At the date of the examination, the water in both bays was thought to be pure or only naturally polluted. Had the presence of the lavoratory-pollution been known an effort would have been made to examine a further stretch of the coast. It would be of great interest to keep these two bays under observation and also others in the neighbourhood, with a view to ascertaining the amount of pollution and the amount of *Ulva*-growth that occurs annually.

Summary and Conclusions of County Antrim Trip.

The inspection of the river-mouths of the Antrim coast did not result in the finding of any large growth of *Ulva*. None of the rivers were badly polluted. From what was observed at Cushendun and Rockport (Belfast Lough), it was obvious that *Ulva* can thrive in water, but very slightly polluted; the absence of *Ulva* therefore round about the mouths of the Antrim rivers cannot without further evidence be attributed to the small amount of pollution; indeed the quantity of *Ulva* seen was in most cases so exceedingly small, as to suggest that the localities were unsuitable for its growth. Some of the factors which may be responsible for this are referred to above, but the subject requires further investigation.

The two Loughs visited for the purpose of comparison with Belfast Lough *i.e.*, Strangford Lough (County Down), and Larne Lough, showed only a small amount of *Ulva*. Both Loughs are probably only slightly polluted by sewage, and both possess sand and mud banks exposed at low water. The general scarcity of *Ulva* compared with Belfast Lough was very striking, but, as in the case of the rivers, it did not appear safe to conclude that the lack of *Ulva* is due to the absence of pollution without further evidence. In both Loughs a small quantity of vigorous *Ulva*-growth was found in certain spots where rocks or other anchorage was present. This suggested that the absence of a firm substratum was largely responsible for the scarcity of *Ulva*, and emphasized the importance of the presence of the mussel-beds at Belfast.

The Giants' Causeway was perhaps the most instructive locality visited. In addition to other points of interest, this spot supplied in a most unexpected way the only case on the tour which supported the view of the invigorating effect of sewage-pollution on *Ulva*. Two bays were examined at the Causeway, in one of which there was natural pollution only, in the other, there was in addition (during summer at all events) considerable pollution from two public lavoratories. In the first bay a fair quantity of *Ulva* was found, in the second the growth was very much greater. The difference in the two bays was very striking, the more so as in every other respect they appeared similar.

Though the general results as to the connection of sewage and the growth of *Ulva* were not decisive, the following four important points bearing on the subject were clearly established.

1. *Natural Pollution.*—Contamination of water similar to that caused by sewage, as measured by ammoniacal nitrogen is produced by the decay of ordinary seaweeds. Pollution of this kind may be termed "natural pollution." It doubtless takes place on a large scale in loughs and sheltered bays, and also to a certain extent along any shore where loose seaweed accumulates.

2. *Formation of Mud.*—A very foul black mud was noted at Strangford Lough which was derived almost entirely from the decay of vegetable matter. It evolved sulphuretted hydrogen when stirred and was quite as foul as *Ulva*-mud, but the weeds from which it was derived were mainly *Zostera* and *Enteromorpha.* This mud doubtless evolves ammonia and fouls the water to a considerable extent.

3. *The Growth of Ulva in the Absence of Sewage.*—At the Giants' Causeway (amphitheatre 1) and at Cushendun, where little if any sewage pollution was present, a small but vigorous growth of *Ulva* was noted. A similar growth was observed at Rockport, a locality in Belfast Lough where pollution is slight.

4. *Firm Substratum.*—The necessity of a firm substratum or other good anchorage for the growth of large *Ulva* fronds was clearly demonstrated throughout the trip, and additional weight was thus given to the importance of the part played by the mussel-beds at Belfast.

With regard to the important discovery of natural pollution (which though long suspected is now proved by analysis), there was evidence to show that, if *Ulva* was dependent upon an abundant supply of ammonia and nitrates, the presence of natural pollution might account for its vigorous growth in certain places visited. The presence of natural pollution also suggested an explanation for the opinion held by the writer, that many localities exist in England where *Ulva* grows in abundance in the absence of sewage pullution. The following trip deals with this subject.

B.—Swanage and Studland, June, 1910.

A brief visit was paid to Swanage in June as the writer had the impression that *Ulva* occurred plentifully in that neighbourhood, and except near sewage-outfalls no pollution was to be expected. A point which was specially kept in view during this trip was the connection of *Ulva* with decaying seaweed. Both Swanage and Studland were visited again in September, as recorded later.

Swanage.

Locality 1. *Below the Grosvenor Hotel, between Swanage Pier and Peveril Point.*—The main sewage outfall is at Peveril Point (at the extreme end of the north reef) about ¼ mile from the pier. There are no small outfalls. Sewage pollution probably very slight. The shore is sheltered facing north and the water is usually tranquil. A fair amount of rotting seaweed was present.

Ulva and *Enteromorpha* was abundant in pools and on rocks immediately above low-water mark and also in the shallow water below. The *Ulva* was mostly lanceolate in form and of medium size, though a few large fronds also were noted.

Locality 2. *Peveril Point.*—Two reefs run out here into the sea parallel to each other, and, except in the shallow water between the reefs, the conditions are "exposed." Although in the immediate neighbourhood of the sewage outfall the pollution is probably not great, owing to the strong current which runs round the Point.

Ulva was found liberally scattered in shallow water between the reefs, and little or no *Ulva* on the reefs themselves; conditions probably too exposed.

Locality 3. *Durlston Head.*—This spot was selected on account of the pureness of the water. The Peveril Point sewage could not appreciably effect Durlston Head, and with the exception of a very small outfall in Durlston Bay there is no other discharge in the neighbourhood. Accumulations of rotting seaweed had not been observed in the immediate vicinity of the Head, and therefore little natural pollution was expected.

Ulva was practically absent from this spot; a few young plants only were noted. The rocks are very exposed and no deep pools exist; the conditions, therefore, are unsuitable for its growth.

Locality 4. *Durlston Bay.*—The Bay is about 1 mile wide, rocky, rather steep and exposed to the south-east. The sewage pollution must be very slight except in the middle of the bay, where there is an outfall draining some twelve houses. The marine flora of this bay, including Peveril Point and Durlston Head, is rich, and several uncommon species are to be found.

Ulva was very plentiful here, especially towards the southern end. The plants, except in sheltered places between rocks where several very fine specimens were collected, were nearly all small.

A well-marked type of *Ulva*-growth occurred on flat rocks near low-water line in Durlston Bay. The rocks concerned are mostly devoid of large seaweeds such as *Himanthalia, Laminaria* and *Fucus serratus*, etc., but are carpetted with a short growth of *Laurencia pinnatifida, Corallina officinalis, Chylocladia ovalis*, etc. *Ulva* occurred abundantly on these flat rocks which, being just exposed at low-water, appeared as green plateaus. It also occurred plentifully, but in patches, on flat rocks below low-water line. The plants were either epiphytic on the short undergrowth, or were attached directly to the rocks by their basal disk. In all cases the plants on the plateaus were small not exceeding 6 or 8 inches in length, usually less; a fact which with little doubt may be attributed to exposure to wave-action. A precisely similar vegetative formation was seen again in September, but the *Ulva*-growth was not quite so striking. It is interesting to note that the plateaus were covered over with a thin layer of decayed vegetable matter and black sand (suggesting that some of the short vegetation decayed *in situ*), which was held together by a dense growth of such plants as *Corallina, Cladostephus*, etc. *Ulva*, therefore, in this position grows over a substratum that is in a constant state of putrefaction.

Studland.

The locality investigated here was some rocky ground under the cliffs that extend from the right-hand corner of Studland Bay to Handfast Point (Old Harry Rocks), and was selected on account of its sheltered position. There is no drainage outfall in the bay and sewage-pollution appeared to be out of the question. A large quantity of rotten seaweed had been found there on previous occasions and therefore much natural pollution might be expected. On the date of the visit (June 8th), a fair amount of decaying weed was found, but most of it occurred near the Point where the conditions are more exposed. An exceptionally low spring-tide favoured the visit.

Ulva was exceedingly common almost the whole way from the corner of the bay to within a short distance of Handfast Point. About half-way along it was abundant, forming a distinct zone in pools and on rocks near low-water line. The plants were almost entirely epiphytic, and were mostly of the lanceolate form, but often of considerable size, fronds 15 to 18 inches long by 10 to 12 inches wide being of frequent occurrence. The rocks were covered with chalky mud, sand, or blackish mud with a fair amount of decaying vegetable matter intermixed. Much of the growth was exposed to the air at low-water, but the greater part, and also the must luxuriant, occurred either in long narrow pools running parallel with the shore, or in shallow water below the low-water level. Owing to the exceptionally low tide it was possible to examine this sublittoral growth, and, at the Studland Bay end of the cliff it was found to extend as far out as the *Zostera*-beds which occur in the bay.

At the Point itself, where the conditions are "exposed," *Ulva* was almost absent; a few small plants occurred on the rocks, and one very large example was noted in a channel which was covered with 3 feet of water even at low tide. The water here appeared to be pure, though on the ebb tide probably much of the natural pollution from the Bay passes round the Point.

In certain of the small bays along the cliffs a very foul black mud was present and a distinct smell of sulphuretted hydrogen was noticeable. The origin of the mud could be traced to decaying seaweeds of which all kinds appeared to be represented. In one spot a considerable quantity of *Ulva* was washed ashore, and formed a narrow ridge about one inch thick at high-water line. In Studland Bay also, *Ulva* was the most conspicuous weed thrown up by the waves.

In addition to *Ulva*, a very luxuriant growth of *Enteromorpha intestinalis* occurred at places on the upper part of the shore. This is doubtless to be explained by the presence of fresh water which oozes in some quantity from the chalk cliffs during the winter months. In September the *Enteromorpha* growth was much less noticeable.

Summary of June Trip to Swanage.

The two most important facts noted on this trip were:—

(1) The occurrence of *Ulva* in abundance in a locality entirely free from sewage pollution (Studland).

(2) The occurrence of a few, large, vigorous fronds of *Ulva* in apparently pure water (*i.e.*, water practically free from both natural and sewage pollution). (Durlston Bay and Handfast Point.)

C.—CLARE ISLAND AND CLEW BAY, JUNE, 1910.

A fortnight was spent in this locality in connection with the Natural History Survey of the district. The time was fully occupied with survey work, but a few points as to the distribution of *Ulva* were noted.

Clare Island is one of the larger islands off the west coast of Ireland; it is fully open to the waters of the Atlantic and is far removed from sewage. Houses and cottages exist on the island, but there is no drainage pollution. Its rock-bound shores present a typically "exposed" type of flora, and except on the east side which is more or less sheltered there is little ground suitable for *Ulva.*

At one locality on this island (Portlea, a somewhat sheltered bay on the east side), *Ulva* was found in fair quantity. Rocks in the bay break the force of the waves, and several large fronds were noticed. The growth occurred in shallow pools about half-tide level. Much loose weed is washed ashore with certain winds, but there did not appear to be any quantity of decayed weed.

Another small bay near Roonagh Point showed a very similar type of growth but more extensive. Roonagh Point is situated on the mainland, but the conditions of exposure and purity of water agree with those of Clare Island. A few houses exist at Roonagh Quay, but there is no direct pollution. A great deal of rotting weed was found in the bay, and at the time of the visit kelp-fires were in progress all along the shore proving that *Laminaria* is thrown up in large quantities. The growth of *Ulva* in this bay, though not covering a large area, might almost be termed abundant.

A second point which was proved beyond question at Clare Island was the presence of healthy *Ulva* in water where natural pollution is absent. The plants occurred in deep pools near low-water line. The shore was semi-exposed and the lie of the rocks prevented any accumulation of loose seaweed. Fresh-water streams were also absent. The pools were completely submerged except at low-water, and even then were often splashed by the waves. The water with which the pools were bathed was beautifully clean and, coming direct from the Atlantic, must be regarded as practically pure. The only natural pollution possible would be that arising from the decay of vegetable or animal matter in the bottom of the pool. Very little matter of this kind was however present and the continual supply of pure water would render pollution from this source negligible. Some half dozen fine *Ulva* plants were noted, the fronds were crisp, of a deep green colour. The sunken position afforded by the pools provided the plants with the necessary shelter.*

Clew Bay.—It was thought that Clew Bay would prove useful for comparison with Belfast Lough, it being a bay of considerable size and affording much sheltered water in its inner portion. The flat shores are, however, largely sandy, and thus are entirely unsuitable for the growth of seaweed; where rocks occurred there was a dense covering of *Fucus.* Time allowed only of the inspection of a limited area and very little *Ulva* was found. It is probable that more suitable ground would have been discovered had it been sought for.

Summary of June Trip to Clare Island and Clew Bay.

The observations made in the Clare Island neighbourhood confirm the results obtained at other places namely:—

(1) That *Ulva* occurs in fair quantities in sheltered bays, where sewage is absent, but where a certain amount of natural pollution may be expected.

(2) That it is possible for *Ulva* to grow and to thrive in pools where both sewage and natural pollution are absent.

The presence of *Ulva* in quantity in sheltered bays which are unpolluted by sewage, but where decaying seaweed is apt to accumulate, is of interest, and is of sufficiently common occurrence to suggest the preference of *Ulva* for these localities. It should, however, be remembered that the protected bays and creeks which afford the sheltered conditions necessary for *Ulva* at the same time often acts as traps for the accumulation of loose weed. It is for this reason that emphasis is laid on the occurrence of a few *Ulva*-plants in pure water.

D.—SWANAGE, WEYMOUTH, AND SOUTHAMPTON, SEPTEMBER, 1910.

The three districts that had so far been examined with regard to *Ulva,* namely, County Antrim, Swanage and Clare Island had each given evidence that *Ulva* could flourish in the absence of sewage. The Swanage neighbourhood, however, had yielded further results. A growth of *Ulva* had been observed at Durlston Bay in water which was regarded as very pure, and at Studland an abundant growth of *Ulva* had been found on a shore where sewage contamination appeared impossible, but where a measure of pollution due to the decay of vegetable and animal matter might be expected. A similar growth was noted at Clare Island, but on a smaller scale. Before definite conclusions could be drawn from these observations it was necessary to ascertain with greater accuracy the condition of the water in the localities in question. The absence of sewage-contamination had to be confirmed, and it was highly desirable to learn somewhat of the amount of fresh water present. It was, moreover, specially important to discover whether the amount of pollution caused by the decay of seaweeds approached in any degree that which is caused by sewage in Belfast Lough. Chemical and bacteriological analyses of the water were necessary for this purpose, and a tour on the south coast of England was planned in order to investigate the subject. The Swanage district was chosen as being the most suitable, as not only could the ground inspected in June be re-examined, but localities such as Weymouth and Southampton, where *Ulva* was known to exist in abundance, were within easy reach.

The tour, which was attended by members and officers of the Commission, took place during the first week in September, and occupied six days. The following is an account of the investigation, to which is appended the analyses of the water-samples and *Ulva*-fronds.

Swanage, September 2, 1910.

Two localities were examined here (Nos. 1 and 4 of the June trip) and samples of water taken from each. The Commission was indebted to Mr. J. Sidney Senior, the Town Surveyor, who readily supplied details as to drainage and other local information.

Locality 1. *Below Grosvenor Hotel* (*between Swanage Pier and Peveril Point*).—For topographical conditions, *see* p. 128.

Ulva and *Enteromorpha* occurred on the rocks and in pools near low-water mark, but the growth of green weeds was considerably less than in the beginning of June. A dense coating of *Chondrus crispus* and young *Fuci* covered many of the rocks of the low littoral zone where *Ulva* usually grows. As before the plants were somewhat lanceolate in shape and of medium size. A certain amount of decaying seaweed was noted.

Two samples of water were taken here, one from amongst the rocks (No. 248), and the other about 50 yards from the shore (No. 247). The analyses showed that the water was very pure chemically compared with that of Belfast Lough, containing only about one-tenth the quantity of ammoniacal nitrogen which is usually present in the inner part of the Lough. The chlorine figure was high, indicating the absence of fresh water.

Locality 2. *Durlston Bay.*—As explained on p. 128 Durlston Bay is rocky, rather steep, and exposed to the south-east. It was expected that the sewage pollution would be very slight, except near the Peveril Point end, and also at a spot in the middle of the Bay where a small outfall drains some twelve houses. A certain amount of decayed weed is, however, often to be found. The flora is fully marine, rich in species, and includes several rare and uncommon plants.

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* A visit paid to Clare Island in October showed an interesting difference in the amount of Green weeds in the rock-pools. The Red and Brown weeds abundant in spring and early summer had for the most part disappeared; and their place was taken by *Enteromorpha* and *Ulva.* Many shallow pools at half-tide level were completely filled with young *Ulva,* the fronds being small (9 to 12 inches long), of a deep green colour, and apparently exceptionally healthy. Autumn growth of this description would doubtless not attain a large size, but would probably continue to grow till torn away by autumn gales or checked by the advent of cold weather.

As was the case with locality 1, there was less *Ulva* here than in June, but on the present occasion the southern half only of the bay was examined. The peculiar *Ulva* plateaus were again in evidence, and a number of small plants were also noted on flat rocks in shallow water. A description of the *Ulva* plateaus is given on p. 128. As in June, the plants were short, and somewhat tough; they were much eaten by *Paludestrina*. No large plants were noted on this occasion (*cf.* June).

A sample of water taken from amongst the rocks showed practically the same nitrogen figures as that from locality 1. Being more open than the latter spot even lower figures had been expected.

Studland, September 3, 1910.

Locality 1. *Studland Cliffs.*—The same ground was examined as on the previous visit, namely, the rocky shore under the cliffs that extend from the right-hand corner of Studland Bay to Handfast Point (Old Harry Rocks). The cliffs face north, consequently the conditions are very sheltered, and seaweed accumulates in quantity. The shore is decidedly flatter than at Durlston Bay, and the zones of vegetation are consequently more conspicuous. Sewage-contamination appeared to be most unlikely. There was a possibility that some of the Poole sewage might find its way to these cliffs; but this was improbable as the sewage in question is discharged at some distance from Studland, *viz.*, on the further (east) side of the entrance to Poole Harbour. The opinion of the Poole authorities based on a knowledge of the currents was also against this possibility.

Ulva was found in plenty from the corner of the bay to within about 150 yards of the Point. About half-way along, the plant occurred abundantly, pools and areas of shallow water being filled with it. The growth formed a bright green zone near the low-water line and extended a considerable distance into the sub-littoral region. At this part of the cliffs the weed was, if anything, more abundant than in June, but towards the Studland Bay end it appeared to be less plentiful. The low littoral and sub-littoral regions of that part of the shore were, however, not examined. Towards the Point, *Ulva* became gradually less. The reason for this was not altogether obvious, as the conditions were apparently the same except for an increase in exposure; the latter, however, did not appear to be great. No *Ulva* was found at the Point.

The character of the growth was similar to that found on the previous visit. It was mostly epiphytic on an undergrowth of *Cladostephus*, *Chondrus*, *Fucus*, etc.; and the fronds were sometimes of considerable size.

Foul mud which gave off sulphuretted hydrogen abundantly when stirred occurred about half-tide level and above in several of the bays. No fresh *Ulva* was found thrown up on the shore as in June. The *Enteromorpha* growth which at that time was so abundant at certain spots near high-water line was very much less.*

Locality 2. *Studland Bay.*—A small growth of *Ulva* was observed in the south corner of the bay which is worthy of note. The tide recedes for some distance and leaves a flat sandy shore devoid of vegetation, except where firm patches of stones afford anchorage. Several patches of this sort exist, and these were mainly colonized by two plants, *Enteromorpha* and *Ulva*. In one case noted *Ulva* was intermixed with *Enteromorpha*, and in another, *Ulva* appeared to have the monopoly. The growth was dense, of a deep green colour, and appeared remarkably healthy. Though the fronds were small, they doubtless attained the size that the somewhat poor anchorage and the motion of the water would allow. These green patches on the otherwise barren shore afforded a striking example of the importance of anchorage.

With regard to the pollution of the water, three samples were drawn for analysis. One from amongst the rocks under the cliffs where *Ulva* occurred in abundance (No. 250), and two others (Nos. 251 and 252) at some distance from the shore. It was with considerable interest that the result of the analyses was awaited, as Studland Bay appeared to afford an instance of a luxuriant and abundant growth of *Ulva* in the absence of sewage pollution. Decayed seaweed doubtless causes pollution and the interest lay in the amount thus contributed, and whether the ammoniacal and albuminoid nitrogen figures would in any degree approach those of Belfast. The analyses showed that this was not the case. The figure for ammoniacal nitrogen in No. 250 was very low, one-tenth the quantity present in the inner part of Belfast Lough and the albuminoid ammonia, though considerably higher in proportion, was below the Belfast figures.

Weymouth, September 4, 1910.

The most important ground to be investigated at Weymouth was the Backwater or Lake, but as time allowed two other districts (viz., the Nothe shore and the Harbour) were briefly inspected. The Commission was indebted to Dr. W. B. Barclay for local information and assistance.

Locality 1. *Shore south of the Nothe.*—The shore here is somewhat sheltered, being protected from the south and west by the island of Portland. The pollution of the water was not ascertained, but it was believed to be slight. The sewage of Weymouth is, however, discharged into the sea at a point not half a mile to the east, and the proximity of Portland Roads, with its floating naval population, should be borne in mind.

Ulva was scattered plentifully on the rocks near low-water line, but was of small size. In shallow water and pools a few large plants occurred. Higher up on the shore some very foul seaweed-mud was noted. Various kinds of algæ contributed to the formation of this mud, and in the upper layers much *Ulva* was recognised. Sulphuretted hydrogen was freely evolved on stirring, and sulphur was copiously deposited on those weeds which were tougher and more resistant to decay. A comparative study of the decay of *Ulva, Zostera*, Wrack and "May Fog," and a knowledge of the amount of sulphur contained, by each, would be of interest.

Locality 2. *The Harbour.*—*Ulva* occurred in abundance at the mouth of the harbour, which constitutes the estuary of the river Wey. When walking from the Nothe to the Bridge at low water the growth was plainly visible, occurring everywhere on piles, and on the sides of the harbour, and also on the bottom. The pollution of the water was not determined, but being a tidal estuary, it would be subject to more variation than the open shore hitherto examined. A single sample of water would therefore be of little value.

Locality 3. *The Lake or Backwater.*—The Lake is a sheet of water that extends from the back of Weymouth town to Radipole. It is about a mile and a half long and, except at the lower end, about half a mile broad. *Ulva* occurs in great quantity in the upper part of the Lake and has to be removed continually during the summer in order to prevent nuisance.

The Lake receives at its northern end the Wey, a river somewhat polluted by crude sewage from a few small villages. At the other end it communicates with the harbour. The whole Backwater is tidal, but the water is impounded at the harbour end by a dam. The gate of the dam is opened at regular intervals to cleanse the Lake. *Ulva* has always been present in great quantity in this sheet of water, and unpleasant smells have existed at intervals for at least 30 years. Quite recently, however, a decided increase in growth has been noted, and this appears to be correlated with an alteration in the topography of the Lake. Three years ago, in connection with railway improvements, a bridge was formed across the Backwater, connected on either side by stone embankments. This had the effect of deflecting what little current existed to the middle of the Lake, and forming on either side a bay of quiet shallow water. During the last three seasons the increase of *Ulva*-growth has been very marked, and, in the opinion of several of the residents, it is connected with the loss of current.

The flora of the lake varies considerably at different seasons of the year. This is equally true of the other localities examined, but in the Weymouth Backwater the effect is more striking. Fewer elements enter into the composition of the flora, and when they do so they occur in large masses and form an almost pure growth. In April, the conspicuous vegetation (at all events in the shallower regions) was a vigorous and growth of *Enteromorpha intestinalis*. No attached *Ulva* was seen, though carefully searched for; at the top end some loose fronds were found, but it was doubtful if they were growing.* In September, two types of vegetation were present. At the lower end the bottom of the Lake was covered with a dense growth of *Enteromorpha clathrata* and *Cladophora gracilis*. The local name for this growth, which is similar to "May Fog" of Ireland, is "Blanket Weed." It was mostly attached and showed no signs of dying down for the season. This growth gradually gave place to *Ulva*, and in the upper part of the lake *Ulva* occurred unmixed. The extreme end was not examined. A very large quantity of the *Ulva* was in a loose floating condition, and at the Radipole end a thick layer was cast up on the shore. Accumulations of weed are frequent in that region, owing doubtless to the prevalency of south-westerly winds.

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* Studland was again visited on November 2nd with Professor Letts and Mr. Richards. By that date the autumn gales had devastated the shore, and none of the luxuriant *Ulva*-growth of September remained. Two long narrow pools showed a large number of small specimens, and with the exception of these and a few loose fronds amongst the sea-weed *debris*, no other *Ulva* was found.

The bottom of the Lake, in the parts examined, consisted of sandy mud with a fair admixture of stones. The anchorage therefore appeared to be poor, but with such extremely quiet water it would probably afford sufficient mooring for good-sized plants. The amount of attached growth was not ascertained.

Ulva had been continuously removed from the Lake since June, and a week previous to the visit, owing to a strong north wind which coincided with the prolonged opening of the weir for repairs, an enormous quantity of loose weed had passed out to sea. From this it will be seen that the amount of *Ulva* that occurs in the Weymouth Lake is fully as great in proportion as that of Belfast.

Turning now to the chemical character of the water, for reasons given above, a certain amount of sewage pollution was expected. The samples of water drawn for analyses (Nos. 253-255) were, however, surprisingly pure. The albuminoid nitrogen figures were higher than those of Swanage and Studland and about equal to those of the inner part of Belfast Lough; but the ammoniacal nitrogen was only one-tenth, or a little over one-tenth, of that found in that locality. It should, however, be borne in mind that the water at the time of the visit was probably at its best, as the weir had been open for eight consecutive days just previously owing to repairs.

The Commission subsequently thought it advisable to obtain further water-samples from the Lake, and Dr. Barclay kindly undertook to supply additional series as required. Samples sent in October and November showed very much higher nitrogen figures, and there can be no doubt that the Backwater is often much more contaminated than on the occasion of the September visit. (see Table on p. 137, and remarks on p. 136.) This view is also borne out by the analysis of the *Ulva* fronds, which were found to contain between 3 and 4 per cent. of nitrogen, an amount not likely to occur in pure water samples. (See remarks on p. 142.)

The proportion of contamination contributed by sewage and natural pollution respectively was not ascertained. There is a constant decay of vegetable matter in the Lake, and the impounded water doubtless allows natural pollution to accumulate to a much greater extent than usual.

The conditions therefore of the Weymouth Backwater must be regarded as exceptional. The dam at the lower end results in particularly still water, but it also acts in other directions. By preventing the entire escape of the water at low tide, pollution, whether sewage or natural, is to a certain extent retained; but at the same time a large amount of loose *Ulva* is thereby able to exist in a floating condition; and the latter as long as it is living would absorb ammonia and thus purify the Lake. It is moreover uncertain whether the water that flows over the weir with the incoming tide is not at times more contaminated than the Lake itself, and this together with the varying concentration of the pollution brought down by the Wey makes the problem additionally complicated.

The locality affords a most interesting field for study and differs in several respects from any other that has been investigated by the Commission. At least one entire season's work would be necessary, as the growth of the weeds is little better understood than the chemical nature of the water. At present the most reliable evidence as to the latter appears to be afforded by the chemical composition of the *Ulva* itself, the high nitrogen-content indicating an abundant supply of nitrogenous food, but precise information as to the origin of this supply is not available.

Poole Harbour, September 5th, 1910.

Poole Harbour, which covers some 14 square miles, is connected with the sea by a narrow opening. It forms therefore a somewhat extensive sheet of quiet and, for the most part, shallow water. Several streams contribute fresh water, but little or no sewage contamination was expected. The sewage of Poole is conveyed some 5 miles from the town, and discharged on the coast outside the harbour so that no pollution was expected from this source. Before the present drainage scheme was inaugurated very little sewage existed at Poole, the water and the bottom of the harbour may therefore be regarded as having always been fairly pure. Mr. S. J. Newman, the Borough Surveyor, readily supplied the Commission with all necessary information.

Time only allowed of the examination of a small part of the harbour; and on the whole very little *Ulva* was found.

Near the town of Poole large beds of *Zostera* occur. The tide was somewhat high for observing *Ulva*, but it appeared unlikely that any quantity was present. In the vicinity of Parkstone Bay the *Zostera*-beds were laid bare, and on some of these *Ulva* was found freely scattered. The plants were invariably attached to stones, shells, or other solid bodies embedded in the mud. Some of the fronds were of large size. Its occurrence under these circumstances indicated that the water was not unsuitable, but that anchorage was essential.

Further south, at the end of Salterns pier, another and very striking example of the importance of anchorage was met with. The general external conditions were the same as in other parts of the harbour, and, except for a small fresh-water stream, the water appeared to be the same as that elsewhere. The solid substratum offered by the piles of the pier afforded a foothold for algæ, and on this a dense growth of *Enteromorpha*, *Ulva*, and a small number of other seaweeds was found. A bed of mussels occurred in (or near) the outfall of the fresh-water stream, and on this again *Ulva* was found in abundance. Yet another example was noted. Amongst the *Zostera* which grew around the pier were numerous plants of *Fucus serratus* These were invariably found to be attached to bricks, stones, or other solid bodies. On the *Fucus* and on the brick-bats *Ulva* occurred in abundance. The readiness, therefore, with which *Ulva* takes advantage of a firm substratum was very marked. The water analysis of this spot (No. 257) may perhaps detract from the strikingness of the illustration. but the important fact remains that without the solid substratum no *Ulva* would have occurred.

A word may be said as to *Fucus serratus*. A heavy plant such as this requires a very firm foothold which is usually afforded by rocks. But at Salterns pier brickbats supplied the anchorage, and in the quiet water of Poole Harbour this was sufficient. The stems of *Fucus* then offered a foothold for *epiphytes*, which, under the conditions obtaining, was seized upon by *Ulva*; on an exposed or semi-exposed shore the usual *epiphytes* would be *Porphyra leucosticta*, *Enteromorpha compressa*, etc. In sheltered places *Ulva* appears rather partial to this *Fucus*, which, being a low-littoral or sub-littoral species, suits it well as to position. *Ulva* had been noted on this plant at Rockport (Belfast Lough), Clare Island and Studland.

The water samples of Poole yielded rather unexpected results. A sample (No. 256) drawn from the main channel near the *Zostera*-beds of Parkstone Bay proved to be exceedingly pure, the ammoniacal nitrogen figures being as low as those of Swanage and Studland. The water in the neighbourhood of Salterns pier (No 257) was on the other hand, decidedly polluted, the ammoniacal nitrogen figure being about half as high as that of Belfast Lough. The albuminoid nitrogen for this locality was also high, and there was an admixture of fresh water to the extent of 11 per cent. The cause of this local pollution was not ascertained, and at the time it was not in the least suspected. The fresh-water stream at once suggests itself as a possible source of impurity, and the presence of mussels recalls the interesting suggestion of Professor Letts as to the excretion of ammonia by these molluscs.

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* It should be mentioned that the eastern side only of the Lake was examined, and that possibly attached *Ulva* might have been found in other parts, and that the bulk of the loose *Ulva* present might have drifted to the western side. On the seashore at the same date large fronds of attached growing *Ulva* were found.

Southampton, September 6 and 7, 1910.

Southampton had been inspected by Professor Letts in 1904, and the account of his visit is to be found in Appendix VI. to the 5th Report of the Commission; the writer had also examined the locality in connection with *Ulva* in November, 1909, *v. Kew Bulletin*, 1910, No. 1. Large quantities of *Ulva* occur in the neighbourhood of Southampton, and with certain winds great masses of weed of various kinds are washed ashore. Tide and wind usually suffice to remove most of the weed and no nuisance of any extent exists. Recent improvements, in the way of land-reclamation between the pier and Southampton West, have also been effective in preventing accumulation of seaweed.

It was thought advisable to obtain a more complete idea of the *Ulva*-growth at Southampton and to learn how the conditions of exposure, pollution, and anchorage compare with those of Belfast. Two low-tides only were utilized for this purpose, but these sufficed with previous investigations to gain a fairly good general knowledge of the extent of the *Ulva*-growth. It was at once evident that to obtain a thorough knowledge of so large a sheet of water, much longer time than was at disposal was required; and with regard to analyses a large series would be necessary before any true idea of the distribution of the pollution could be obtained. The inflow of water from the Itchen and the Test, and the peculiar double tides render the locality particularly complicated, Much weight, therefore, must not be placed on the analyses of the water-samples that were collected on a two-day visit. The Commission were indebted to Mr. J. A. Crowther, Engineer to the Corporation for information and advice.

In a general way a certain amount of sewage-pollution must be expected in the neighbourhood of Southampton. Two rivers flow into Southampton Water in the upper part. The Test at the north-west corner, which passes through some small towns and villages; and the Itchen on the east side into which practically all the sewage effluent of Southampton and Eastleigh is discharged, and which, therefore, must be regarded as badly polluted.

The following localities were investigated. The first three are on the east side of the Water, and are taken in order from south to north; the last two are above the town of Southampton.

Locality 1. *Mouth of Hamble River.*—The Hamble joins Southampton Water about two miles below Netley, and therefore some five miles below the mouth of the polluted Itchen.

The flora of this region consisted mostly of large beds of *Zostera* which, as is well known, is capable of growing in soft mud or sand without anchorage. Scattered freely amongst the *Zostera* occurred *Ulva*, attached to solid bodies in the mud. This was so invariably the case that if stones or shells were desired they could at once be obtained by pulling up *Ulva*-fronds. A sample of the Hamble water (No. 258), collected at about 300 yards from its mouth proved to be very pure, containing less than one-tenth of the ammoniacal nitrogen present at Belfast. As this sample was taken one hour before low water it would appear that the Hamble itself is a pure stream.

Locality 2. *Netley.*—On the shore below Netley Hospital a large quantity of mussels exist, and these mussel-beds were observed to extend about half a mile in a southerly direction. The shore to the north of Netley was not, explored. A sewage outfall exists below the hospital, and a certain amount of local pollution is doubtless present.

A copious and vigorous growth of *Ulva* was found on the mussels at the particular spots examined, and it probably occurred in equal abundance the whole length of the mussel-beds. The *Ulva* was very firmly attached by mussel-byssus as at Belfast.

A sample of water (No. 260), taken at a point about ¼ mile below the sewage-outfall and close to the shore proved to be much purer than was expected, containing only very little more ammoniacal nitrogen than the Hamble sample. The albuminoid nitrogen figure was however high. The sample was taken at low water, when the pollution would probably not be less than the average amount.

Locality 3. *Mouth of the Itchen.*—Immediately below the mouth of the Itchen extensive mussel-beds occur near low-water level. The beds present a precisely similar appearance to those of Belfast, and were covered with an abundant growth of *Ulva*. In places the mussels formed banks which showed as islands at low-water.

This spot is, with little doubt, in the direct line of pollution from the Itchen. The abundance and large size of the mussels in a badly-polluted area is a point worthy of note, and one on which further information is desirable.

Locality 4. *Millbrook.*—By means of a boat the flora on either side of a small creek that exists here was examined. The upper part consisted mostly of *Zostera*; further down mussels occurred amongst the *Zostera* and with them *Ulva*. At a lower level there were broad areas of mussels and *Ulva*, and at the lowest zone *Zostera* again was the principal weed. The mussels did not form such dense masses as at Belfast, and the individual mussels were of smaller size. The *Ulva*-growth consequently was not so thick. The general appearance suggested that the beds were in process of formation and that the mussels were young, a view which was supported by local boatmen, who stated that the beds were spreading rapidly. In certain positions in the creek very large fronds of *Ulva* occurred, and in others there were patches of mussels which were entirely devoid of vegetation. The explanation of this is probably to be found in the current draining the channel, which in some places strikes the banks with more force than in others.

Locality 5. *Crackmore Hard.*—Leaving Millbrook and proceeding straight across to the opposite side of the water, the shore was examined from that point down to Crackmore Hard. *Zostera* was abundant and also *Ulva*.

A different character of *Ulva*-growth to that found elsewhere was noted in this region. A large quantity was detached and floating amongst the *Zostera* and had doubtless drifted there from other parts of the Water: the fronds were perfectly healthy, often of large size and evidently growing. In addition to these, a growth occurred in which part of the fronds were buried in mud, and at first sight they appeared as if attached to the bottom, but a very slight pull sufficed to detach them. Growth of this nature was evidently favoured by the quiet weather that had preceded the visit, and would be easily disturbed by wind or rough water. It doubtless only occurs in localities that are particularly sheltered, but serves to show that *Ulva*, which at first grew in the normal way attached to mussels or stones, can on detachment grow and increase under special conditions. This type of growth also occurs at Belfast. Further on, on either side of Crackmore Hard, mussels were found, and on these *Ulva* occurred everywhere.

The connection of mussels and *Ulva* at this spot was very striking and somewhat different to that noted in other parts. In certain places there was a dense sward of short *Ulva* occurring on a bed of mussels, and in others the mussels were scattered. The bottom was firm and composed of a muddy sand. Tufts of *Ulva* were scattered all over the firm shore, and in every instance they were found attached to a buried, or half-buried, mussel. In most cases a few pebbles occurred with the mussel, and the latter was not at first sight obvious. The pebbles, however, were found to be fixed by the mussels just in the same way as was the *Ulva*. This type of growth—a mussel embedded in the sand holding together a little group of pebbles and supporting a flag-like growth of *Ulva*—afforded a pretty and a striking object-lesson of the importance of mussels as a means of anchorage. The shore appeared as if swept by a strong current, and there could be little question that if it were not for the molluscs no *Ulva* would have been present. The mussels also without doubt aid materially in fixing the shore.

A sample of water (No. 261), was drawn between Millbrook and Crackmore Hard. It was found to be less pure than the previous ones taken in the Hamble and at Netley, containing considerably more ammoniacal nitrogen and giving a very high figure for albuminoid nitrogen. The ammoniacal nitrogen figure was about one half that usually present in Belfast Lough.

Loose Weed on the Foreshore.—As noted above, practically no seaweed-nuisance now occurs at Southampton. A considerable quantity of weed, however, was noted on the shore in places, and this has at times to be removed by the Corporation. Between Southampton West and Millbrook, loose *Ulva*, *Zostera*, and "Flannel Weed" were freely distributed over the flat shores, and in certain spots the weed collects in banks near high-water line. For the most part these banks were quite sweet and showed no signs of putrefaction, a fact which is probably to a large extent explained by the stony beach which allows drainage and aeration. In places decayed "Flannel Weed" occurred, which emitted an objectionable smell (*v.p.* 124).

In a few sheltered corners large accumulations of rotten seaweed were noted, and from some of these, sulphuretted hydrogen was being freely emitted. At Millbrook a bad patch of this kind occurred, composed largely of *Ulva*, and the white paint of boats in the neighbourhood was stated to turn black at times. In another spot a bad-smelling bank, composed almost entirely of *Zostera*, occurred. At Crackmore Hard, much rotten *Ulva* was found, and also the "*Ulva*-Mud" of Belfast, *i.e.*, a foul black mud derived entirely from *Ulva*-fronds (*v.p.* 123). Judging from previous visits and from the present, it was obvious that on the whole of the upper part of the western side of Southampton Water, *Ulva* is washed ashore in profusion. Between Netley and Southampton the weed was also reported to be washed up abundantly, a circumstance which is only to be expected considering the extent of the mussel-beds.

Annual Discolouration of the Water.—Another point may be mentioned in conclusion, namely, the annual occurrence of a red colouration of the water. The phenomenon is referred to by Professor Letts, in Appendix VI. to the 5th Report, p. 406. In July and August large areas of water turn a brownish red colour, and acquire a peculiar odour. The colouration was found to be due to myriads of a minute organism belonging to the *Peridineæ*. These organisms, which are on the border-line between the plant and animal kingdoms, frequently occur in shoals, and colour the water or cause phosphorescence. The particular species in question appears to be a species of *Peridinium*, but it was in the swarm-spore stage, so could not be determined with certainty. The colouration is complained of by boatmen, who regard it as detrimental to fishing.

Summary of Visit to Southampton.—The prevailing weed in Southampton Water is *Zostera*, but in certain parts an extensive and abundant growth of *Ulva* is present. In the latter case the necessary anchorage is nearly always supplied by mussels. Mussel-beds were noted at Millbrook, Crackmore Hard, near Netley, and below the mouth of the Itchen. Where there were no mussels there was practically no *Ulva*. A possible exception to this statement is found in localities where drift-*Ulva* occurs in a growing state amongst *Zostera*.

It appears likely that if the mussel-beds in Southampton Water were to increase to any large extent, trouble might follow owing to the increase of *Ulva*. The configuration, however, of Southampton Water apparently allows loose weed to escape more easily than at Belfast.

Areas of sewage pollution occur in Southampton Water, but the precise extent and degree of pollution cannot be determined without an extensive series of analyses.

SUMMARY OF SEPTEMBER TOUR ON SOUTH COAST.

The tour on the south coast was useful and instructive in several ways. The importance of the ecological conditions of shelter and anchorage were clearly demonstrated, and the special questions with regard to pollution on which some doubt existed were cleared up at any rate in the case of certain places. In addition to this a wider view of the distribution of *Ulva* was obtained than perhaps on any previous trip; its ubiquity and readiness to settle down on practically any coast that offered shelter and anchorage was most apparent. The most important observations may be summarised under the following headings:—

1. *Fresh Water.*—It was clearly seen at Swanage and Studland that *Ulva* can thrive in localities where fresh water is almost or entirely absent. At Swanage (Locality 2) the water was fully saline, and at Studland not more than about 1 per cent. of fresh water occurred. In most other places, however, where *Ulva* was found in abundance a considerable amount of fresh water was present.

2. *Natural Pollution.*—There was some evidence to show that *Ulva* was specially plentiful in localities where dead seaweed collected. The amount of pollution from this source, as estimated by ammoniacal and albuminoid nitrogen, appeared to be insignificant. At Studland, where dead seaweed accumulates, and where *Ulva* is abundant, the ammoniacal nitrogen figure was very low. It should be borne in mind that localities on the sea-shore, which offer the sheltered conditions necessary for *Ulva*, are often at the same time those where loose seaweed would naturally accumulate.

3. *Sewage Pollution.*—Swanage and Studland also clearly proved that *Ulva* is capable of growing in the absence of any material sewage-pollution. At Swanage (Locality 2), where the coast is somewhat exposed, and where there are many competing species, the growth is short and it occurs in patches. At Studland, where the coast is sheltered, the fronds are much larger, and the growth abundant. The quiet water and general conditions are favourable to the plant, and enable it not only to hold its own, but to crowd out other species. In both these localities the amount of ammoniacal nitrogen present in the water was only one-tenth of that present in the inner part of Belfast Lough.

4. *Anchorage.*—The importance of a firm substratum to act as an anchorage was a point which was perhaps more forcibly demonstrated than any other (*v.* Poole, Southampton (Localities 1 and 5) and Studland (Locality 2). In such places as Poole Harbour and Southampton Water where anchorage was absent there was no *Ulva*, where it was present *Ulva* almost invariably occurred. This appeared to be irrespective of the amount of sewage pollution.

5. *Mussels.*—The important part played by mussels in connection with an excessive growth of *Ulva* was very marked. These molluscs like *Zostera* can cover ground on which *Ulva* could find no anchorage, but, unlike *Zostera*, they afford a mooring for the *Ulva* and, moreover, a particularly secure one. The presence of mussels and an excessive growth of *Ulva* in estuaries will probably be found to be very intimately connected. Mussels are capable of covering many acres on flat shores which would otherwise be bare mud or fields of *Zostera*, and the result of the mussel-covering is a growth of *Ulva*.

The connection of mussels and sewage is therefore very important and is a point on which accurate information is most desirable.

CHEMICAL ANALYSES OF WATER SAMPLES, TOGETHER WITH A FEW NOTES, BY DR. G. McGOWAN AND MR. COLIN C. FRYE.

The following tables give the chemical analyses of the samples of sea water taken during the Commission's tour on the South Coast in September, 1910. Each table is prefixed by a few notes as to how the samples were drawn, and also by one or two notes on the results of the analyses.

SWANAGE AND DURLESTON BAY—SEPTEMBER 2ND, 1910.

Three samples of sea water were drawn in this neighbourhood.

No. 247. 12 noon. Three-quarter ebb. Sea calm. Near Swanage pier and 50 yards from shore.

No. 248. 2.30 p.m. Low water. Sea calm. Among seaweed on shore close to Swanage pier.

No. 249. 3.30 p.m. One hour after low water. Sea calm. From rock in centre of Durleston Bay, upon which *Ulva* was growing.

The analyses show that these samples were all very pure, chemically, as compared with the water of Belfast Lough. They contained about one-tenth the quantity of ammoniacal nitrogen which is usually present in the water of the inner portion of Belfast Lough.

The chlorine figures show that the sea-water at Swanage could have received very little fresh water in the locality.

Number of Sample	247.	248.	249.
Drawn	Friday, September 2nd, 1910, 12 noon. 50 yards off shore off the Grosvenor Hotel and near jetty.	Friday, September 2nd, 1910, 2.30 p.m. Among seaweed just off Grosvenor Hotel, about low water.	Friday, September 2nd, 1910, 3.30 p.m. Off rock near centre of Durleston Bay, 300–400 yards south of small outfall.
Analysed	September 5th, 1910.	September 5th, 1910.	September 5th, 1910.
	Parts by Weight per 100,000 *Volumes.**		
Ammoniacal nitrogen	0·001	0·002	0·002
Albuminoid nitrogen	0·006	0·009	0·010
Nitrous nitrogen	0·00	0·00	0·00
Nitric nitrogen	0·004	0·000	0·006
Chlorine	2024	2032	2038
Oxygen in solution (when analysed)	† 0·81	1·33	1·30
Dissolved oxygen taken up in 5 days at 18° C	0·02	0·12	0·09
Remarks	Clear and bright.	Clear and bright.	Clear and bright.

* *i.e.*, Grammes per 100,000 c.c.

† 1·0 part of oxygen by weight per 100,000 is equal to 7·0 c.c. Oxygen per litre.

STUDLAND BAY—SEPTEMBER 3RD, 1910.

Three samples of sea water were drawn.

No. 250. 3.15 p.m. Among rocks and *Ulva* about 30 yards from high water mark, at a point rather more than half way between Studland and Old Harry Rock. Forty-five minutes before low water. Sea calm.

No. 251. 4 p.m. Two hundred yards from cliffs and off same point as No. 250. Low water. Sea calm.

No. 252. 5.30 p.m. One and a half hours after low water. Taken 300 yards off shore near tea shanty. Sea calm.

The analytical figures show that these samples contained less than one-tenth the quantity of ammoniacal nitrogen usually present in the water of Belfast Lough. Here, again, the chlorine figures show that the sea-water at Studland Bay could have received very little fresh water.

Number of Sample	250.	251.	252.
Drawn	30 yards from cliffs and high water mark, and about centre of cliffs, 3.15 p.m., September 3rd, 1910.	200 yards from shore, just outside bay in which *Ulva* was growing in abundance, 4 p.m., September 3rd. 1910.	300 yards from shore, in front of tea shanty, 5.30 p.m., September 3rd, 1910.
Analysed	September 5th, 1910.	September 5th, 1910.	September 5th, 1910.
	Parts by Weight per 100,000 *Volumes.*		
Ammoniacal nitrogen	0·0014	0·0011	0·0012
Albuminoid nitrogen	0·014	0·0071	0·0084
Nitrous nitrogen	0·00	0·00	0·00
Nitric nitrogen	0·010	0·004	0·008
Chlorine	2000	2012	2020
Oxygen in solution (when analysed)	1·03	0·97	0·99
Dissolved oxygen taken up in 5 days at 18° C	0·09	0·09	0·25
Remarks	Rather turbid with fine suspended matter. Faint sea smell.	Clear and bright. Merest trace of solids. No smell.	Clear and bright. Merest trace of solids. Faint sea smell.

WEYMOUTH—SEPTEMBER 4TH, 1910.

Three samples were drawn in the Weymouth backwater.

No. 253. 2.45 p.m. One hundred yards off centre of railway promenade, and amongst a profuse growth of "May fog."

No. 254. 3.30 p.m. In centre of backwater between the railway and the Swannery. *Ulva* plentiful.

No. 255. 4 p.m. Under railway bridge near tide weir. Fairly deep water with much weed, mainly "May fog," on bottom.

These samples contained about one-tenth (in one case, No. 253, rather more than one-tenth) the quantity of ammoniacal nitrogen usually present in the Belfast Lough water. The albuminoid nitrogen figures of Nos. 253 and 254 are high compared with those obtained with the Studland and Swanage waters, and the figures for dissolved oxygen absorbtion in five days are also relatively high. The chlorine figures indicate local admixture of fresh water to the extent of about 7 per cent. in Nos. 253 and 255, and of about 14 per cent. in No. 254 (on the assumption that the undiluted salt water would give 2,000 parts of chlorine.)

Number of Sample - - - - -	253.	254.	255.
Drawn - - - - - - -	2.45 p.m., September 4th, 1910. Backwater, 100 yards off centre of railway promenade. (Sample kept in ice, 5th–6th.)	September 4th, 1910. Backwater, middle, between railway and swannery. (In ice, 5th–6th.)	September 4th, 1910. (In ice, 5th–6th.) Backwater, under railway bridge.
Analysed - - - - - -	September 6th, 1910.	September 6th, 1910.	September 6th, 1910.
	Parts by Weight per 100,000 *Volumes.*		
Ammoniacal nitrogen - - - -	0·0026	0·0015	0·0014
Albuminoid nitrogen - - - -	0·026	0·038	0·017
Nitrous nitrogen - - - - -	0·00	0·00	0·00
Nitric nitrogen - - - - -	0·002	0·002	0·002
Chlorine - - - - - - -	1870	1764	1880
Oxygen in solution (when analysed) -	1·02	1·18	1·11
Dissolved oxygen taken up in 5 days at 18° C	0·33	0·42	0·12
Remarks - - - - - - -	Faintly opalescent, with fine suspended solids. Faint fishy smell.	Somewhat opalescent, with fine suspended solids. Strong, sweet, decayed seaweed smell.	Some fine suspended solids. No smell.

POOLE HARBOUR—SEPTEMBER 5TH, 1910.

Two samples were drawn.

No. 256. 4.15 p.m. In main channel between Poole and the mouth of the harbour, off bank called the Round Mud. Very little *Ulva*, but no anchorage. One and three-quarter hours before low water.

No. 257. 5.50 p.m. At end of Salterns pier, where much *Ulva* was growing on anchorage afforded by stones, bricks and mussels. Low water.

Sample No. 256 contained less than one-tenth the quantity of ammoniacal nitrogen usually present in the Belfast Lough water, while No. 257 was much less pure in this respect and contained about half as much as Belfast Lough water. The albuminoid nitrogen figure for No. 257 is high. The chlorine figures indicate local admixture of fresh water to the extent of about 6 per cent. for No. 256, and of about 11 per cent. for No. 257.

Number of Sample - - - - - - -	256.	257.
Drawn - - - - - - - - -	September 5th, 1910, 4.15 p.m. Drawn off Round Mud in mid channel from Poole to mouth of harbour. (In ice, 6th–7th.)	September 5th, 1910, 5.50 p.m. At end of Salterns Pier. (In ice, 6th–7th.)
Analysed - - - - - - - -	September 7th, 1910.	September 7th, 1910.
	Parts by weight per 100,000 *Volumes.*	
Ammoniacal nitrogen - - - - - -	0·0011	0·0057
Albuminoid nitrogen - - - - - -	0·0116	0·023
Nitrous nitrogen - - - - - - -	0·00	0·00
Nitric nitrogen - - - - - - -	0·000	0·000
Chlorine - - - - - - - - -	1910	1798
Oxygen in solution (when analysed) - - -	1·15	0·90
Dissolved oxygen taken up in 5 days at 18° C - -	0·04	0·17
Remarks - - - - - - - - -	Clear; trace of suspended solids. Faint earthy smell.	Clear; trace of solids. Faint earthy smell.

SOUTHAMPTON—SEPTEMBER 6TH, 1910.

Three samples were drawn.

No. 258. 5.30 p.m. Three hundred yards up the Hamble River Estuary. Just before low water. *Ulva* growing wherever anchorage existed.

No. 260. 6 p.m. One-quarter of a mile below the sewage outfall from Netley Nospital and close to shore. *Ulva* plentiful on mussels. Sample was noted as having a distinctly objectionable smell.

No. 261. 9 a.m. (7th). In main channel of the Test Estuary between Milbrook station and Crackmore Hard. About two hours after low water. The water in this part of Southampton water was coloured red with myriads of small red animalculæ (thought to be a species of *Peridinium*, one of the *Peridineae*), and it had a strong wormy smell on shaking. Very large quantities of *Ulva* were growing in this neighbourhood.

Samples Nos. 258 and 260 contained about one-tenth the quantity of ammoniacal nitrogen which is usually present in the Belfast Lough water, but they gave high figures for albuminoid nitrogen.

Sample No. 261 was much less pure; it contained about half as much ammoniacal nitrogen as in the case of Belfast Lough water. It gave a very high figure indeed for albuminoid nitrogen, this result being due not only to matter in suspension (largely animalculæ), but also to matter in solution.

The chlorine figures indicate that samples Nos. 258 and 260 contained about 4 per cent., and sample No. 261 about 20 per cent. of fresh water.

Number of sample	258.	260.	261.
Drawn	5.30 p.m., September 6th, 1910, Hamble River, 300 yards up. Nearly low water.	6 p.m., September 6th, 1910. ¼ mile below Netley Pier and outfall.	9 a.m., September 7th, 1910. In main stream between Milbrook Station and Crackmore Hard.
Analysed	September 8th, 1910.	September 8th, 1910.	September 8th, 1910.
	Parts by Weight per 100,000 *Volumes.*		
Ammoniacal nitrogen	0·0011	0·0016	0·0066 (0·0066 p.f.)*
Albuminoid nitrogen	0·031	0·040	0·23 (0·13 p.f.)
Nitrous nitrogen	0·00	0·00	0·00 (0·00 p.f.)
Nitric nitrogen	0·002	0·006	0·00
Chlorine	1940	1960	1624
Oxygen in solution (when analysed)	0·90	0·71	0·68
Dissolved oxygen taken up in 5 days at 18°C	0·45	0·35	0·68 + x †
Remarks	Clear, fair amount of fine grey suspended solids. No smell.	Clear, small amount of fine pale suspended solids. Very faint earthy smell.	Rather turbid, and red with small animalculæ; strong wormy smell. *N.B.*—Sample had a most objectionable smell after keeping.

* p.f. = paper-filtered.

† " + x " means that no oxygen was left in the sample after 5 days' incubation.

The following table (p. 137) refers to samples of water from the Lake at Weymouth forwarded by Dr. W. B. Barclay, the Medical Officer of Health. The samples were all drawn on October 24th, 1910, and were sent to Dr. McGowan for analysis.

It will be seen that the ammoniacal nitrogen in all of these samples (excepting No. 1) is comparable in quantity with that in Belfast Lough water; the albuminoid nitrogen in Nos. 5 and 6 is distinctly high. The figures for dissolved oxygen-absorption in 4 days are all high, especially in Nos. 3, 5, and 6; while the figures for chlorine in Nos. 4, 5, and 6 show very clearly the different degrees of admixture with fresh river water.

WATER-SAMPLES FROM WEYMOUTH LAKE, OCTOBER, 1910.

Number of Sample	1.	2.	3.	4.	5.	6.
Nature of Sample	From Weymouth Backwater, flowing over weir shortly before high water.	From centre of Backwater, opposite G.W.R. engine sheds, slightly N. of swannery. At high-water.	Radipole: From top of Weymouth Backwater in the current of the river, main channel, near the borough boundary.	Taken at slack water following high water, opposite Abbott's Court.	Drawn near mouth of stream entering west side of the Backwater during slack water, following high tide.	Drawn from River Wey at the top of Backwater, at low water.
		Depth, over 3 feet.	Depth, slightly over 3 feet.	Depth, 3 feet.	Water, 2 feet deep.	Depth, 18 inches.
Drawn	Monday, October 24th, 1910.					
	10.30 a.m. Water not over clear—cloudy.	11.0 a.m. Water cloudy.	11.5 a.m. Water cloudy.	11·15 a.m. Water not clear—(slightly cloudy).	11.20 a.m. Very cloudy	5.0 p.m. Water cloudy.
Analysed	October 25th, 1910.	October 25th, 1910.	October 25th, 1910.	October 25th, 1910.	October 25th, 1910.	October 25th, 1910.
Parts by weight per 100,000 volumes—						
Ammoniacal nitrogen	0·005	0·013	0·010	0·010	0·010	0·013
Albuminoid ,,	0·011	0·012	0·011	0·016	0·033	0·022
Nitrous ,,	0·00	0·00	0·00	0·00	0·00	0·00
Nitric ,,	0·000	0·000	0·272	0 026	0·128	0·245
Chlorine	2064·0	1954·0	50·2	1772·0	1036·0	178·0
Oxygen in solution (when analysed)	0·84	0·82	1·05	0·98	1·00	1·04
Dissolved oxygen taken up at 18·3° C. (65° F.) in 24 hours	0·07	0·09	0·16	0·10	0·13	0·13
Dissolved oxygen taken up at 18·3°C. (65° F.) in 4 days.	0·49	0·63	1·12	0·70	0·91	0·91
Remarks:— Wind E. by N. High water, 11.4 a.m.	No colour, but rather opalescent. Trace of fine suspended matter. No smell.	Rather opalescent. Considerable fine greyish coloured suspended matter. No smell.	Bright-looking and clean. Slightest trace of suspended matter. No smell.	Considerable opalescence and suspended matter. Very slight fishy smell.	Brownish and very turbid. Considerable fine brownish suspended matter. Slight fishy smell.	Rather brownish and opalescent. Considerable very fine brownish suspended matter. Slight but distinct earthy smell.

BACTERIOLOGICAL ANALYSES OF WATER—BY DR. A. C. HOUSTON.

Description of Sample.	Number of Microbes per c.c.		B. Coli Test. T. = Typical B. Coli. N.T. = Non-Typical B. Coli.					B. Enteritidis Sporogenes Test.	
	Gelatine.	Agar.	100 c.c.	10 c.c.	1 c.c.	·1 c.c.	·01 c.c.	10 c.c.	1 c.c.
No. 247.—Sea water taken at Swanage, near Grosvenor Hotel, 12 noon, September 2nd, 1910.	74	11	T. +	0				0	
No. 248.—Sea water taken at Swanage, off Grosvenor Hotel at low water 2.30 p.m., September 2nd, 1910.	8	15	N.T. +	0				0	
No. 249.—Sea water taken at Swanage, Durleston Bay, September 2nd, 1910.	2	5	T. +	T. +	0			0	
No. 250.—Sea water taken from Studland Bay, 30 yards from cliffs September 3rd, 1910.	700	11	T. +	T. +	N.T. +	0		0	
No. 251.—Sea water taken from Studland Bay, 200 yards from shore, 4 p.m., September 3rd, 1910.	14	1	0					0	
No. 252.—Sea water taken from Studland Bay, 300 yards from shore, 5.30 p.m., September 3rd, 1910.	142	2	0					0	
No. 253.—Taken at Weymouth from backwater off centre of Railway Promenade, 2.45 p.m., September 4th, 1910.	38	8	T. +	0				0	
No. 254.—Taken at Weymouth from backwater near swannery, 3.30 p.m., September 4th, 1910.	21	9	T. +	0				0	
No. 255.—Taken at Weymouth from backwater under railway bridge, 4 p.m., September 4th, 1910.	12	6	T. +	0				0	
No. 256.—Sea water taken in Poole Harbour in main channel, 4.15 p.m., September 5th, 1910.	22	3	T. +	0				0	
No. 257.—Sea water taken in Poole Harbour Salterns Pier, 5.50 p.m., September 5th, 1910.	47	7	T. +	T. +	0			0	
No. 258.—Sea water taken at Southampton, Hamble River, 5.30 p.m., September 6th, 1910.	74	36	T. +	T. +	N.T. +	0		0	
No. 259.—Sea water taken at Southampton, below Netley, water polluted with sewage, 6 p.m., September 6th, 1910.	52	16	N.T. +	T. +	T. +	T. +	0	0	
No. 260.—Sea water taken at Southampton, below Netley Hospital, 6 p.m., September 6th, 1910.	135	72	T. +	T. +	T. +	T. +	0	0	
No. 261.—Sea water taken at Southampton, off Milbrook, contained small red animalculæ, September 7th, 1910.	1,100	150	T. +	T. +	T. +	0		0	

Bacteriological Analyses of Weymouth Water Samples.

Description of Sample.	Number of Microbes per c.c. Agar at 37° C.	Number of Microbes per c.c. Gelatine at 20° C.	B. Coli Test. T. = Typical. N.T. = Non-Typical.						B. Enteritidis Sporogenes Test.	
			100 c.c.	10 c.c.	1 c.c.	·1 c.c.	·01 c.c.	·001 c.c.	10 c.c.	1 c.c.
I.—Water from Weymouth Backwater, flowing over weir shortly before high-water, not over clear, cloudy. High water, 11·4 a.m. Wind, E. and N. October 24th, 1910.	18	92	T. +	T. +	T. +	—			—	
II.—From centre of Backwater off G.W.R. engine sheds, and slightly north of swannery. Depth over 3 feet; water, cloudy. Taken 11 a.m., October 24th, 1910, high water.	21	45	T. +	T. +	T. +	—			—	
III.—Radipole; from top of Backwater in the current of the river. High water, 11.5 a.m., October 24th, 1910.	1,260	15,300	+	+	T. +	N.T. +	T. +	—	+	—
IV.—Testbury, at slack water following high water at 11.15 a.m., off Abbot's Court. Depth 3 feet; slightly cloudy, Wind, E. and N. October 24th, 1910.	30	100	T. +	T. +	T. +	—			—	
V.—Drawn near mouth of stream, on west side of Backwater at 11.20 a.m.; water very cloudy, 2 feet deep, October 24th, 1910.	55	340	T. +	T. +	N.T. +	—			—	
VI.—Drawn from River Wey, top of Backwater, at low water, Water cloudy; depth, 18 inches, October 24th, 1910, 5 p.m.	540	9,800	+	T. +	T. +	N.T. +	—		+	—

ANALYSES OF *ULVA* FRONDS.

Table showing the content of nitrogen, sulphur and phosphorus in *Ulva* from various localities.

The high percentage of nitrogen in the Belfast specimens compared with those from unpolluted districts is very marked. The samples were analysed by Professor Letts and Mr. Richards and the results were expressed as percentages on the dried weeds. For remarks on the composition of *Ulva*, see p. 142.

	Nitrogen.	Sulphur.	Phosphorus.
Belfast Lough (polluted) - - - - - -	3·80	4·06	0·18
,, ,, ,, - - - - - -	4·31	4·00	0·28
,, ,, ,, - - - - - -	4·75	5·42	0·23
,, ,, ,, - - - - - -	4·30	4·42	—
,, ,, ,, - - - - - -	3·59	4·24	—
Larne Lough (probably slightly polluted) - -	2·53	2·63	0·11
Strangford Lough (unpolluted) - - -	1·65	2·21	0·12
Clare Island (unpolluted) - - - - - -	1·73	—	—
Durlston Bay (unpolluted) - - - - -	1·13	5·36	0·10
Studland (unpolluted) - - - - - -	1·18	5·38	0·06

PART III.

GENERAL RESULTS OF THE BOTANICAL INVESTIGATION, AND CONCLUSIONS.

Three special trips were undertaken to study the ecology of *Ulva* (*i.e.*, the plant in relation to its enrivonment), and to note especially the factors which appeared to favour excessive growth. The localities are dealt with *seriat'm* in the report, and each will be found to have yielded results of interest.

It should however be remembered that, considering the nature of the subject, the portion of coast-line that has been examined, and the amount of time that has been spent on the study are very small. The subject was in the hands of the writer for less than a year, and it is impossible to expect the ecology of any plant to be understood by means of a few short visits to the coast during a single season. The relative importance of the different factors has not in all cases been definitely settled, and there are many points still requiring explanation. The results that have been obtained are summarized below under the heading, "general ecology of *Ulva*." This is followed by a discussion of the conditions which are considered to be important in connection with its growth in excessive quantity.

1. THE GENERAL ECOLOGY OF ULVA.*

General Distribution in the British Isles.—Though the tours which were undertaken were not sufficiently extensive to clearly demonstrate the fact, it should be stated that *Ulva* is widely distributed on our shores and that the spores may be assumed to be everywhere present. Wherever therefore conditions are suitable, *Ulva* may be expected to appear.

Vertical Distribution on the shore.—On an ordinary shelving shore *Ulva* is found; (1) from half-tide level and downward exposed to the air as a littoral plant; (2) in shallow water beyond the low-water level (sublittoral); and (3) in rock-pools at any level on the shore. (The conditions in pools are not littoral but are more in agreement with those of the sub-littoral region). The vertical distribution of weeds on a shore is chiefly dependent on two factors, namely illumination and desiccation. The position occupied by *Ulva* therefore indicates that it prefers moderate or much light, but that it cannot stand the desiccation of the upper littoral region. Some writers have stated that *Ulva* is found to a depth of 5 or even 10 fathoms; in the investigations above described it was not noted as growing in more than 4 or 5 feet below low water mark). Its occurrence in deeper water would have to be ascertained by dredging, an operation which was not considered necessary in connection with the present investigation.

Effect of Exposure.—*Ulva* is found on sheltered, and on moderately exposed coasts. On very exposed positions where the full force of gales and storms is felt, *Ulva* has not been noted, or at all events not as a littoral plant.

In moderately exposed coasts such as Durlston Bay, and the east side of Clare Island, *Ulva* is of common occurrence as a littoral, sublittoral, and pool plant. The form with an oblong-lanceolate frond and a tapering base is common in such localities, but it is found to pass by transitions into the broader and umbilicate types. The growth of the littoral plant is nearly always short, and often tough and crisp, the latter character apparently increasing with the amount of exposure. In pools on a fairly exposed coast, *Ulva* occurs at times in profusion and may even attain considerable size.

But it is in sheltered localities that the greatest development is met with. In the absence of rough water the plants grow to a much larger size and often form a distinct "association." Here again the littoral and sublittoral growth may be distinguished. The littoral growth can at times be traced as a perfectly distinct line following the course of the rocks immediately above low-water level (Studland). This growth passes into the littoral zone where it continues to form a luxuriant vegetation in several feet of water, the largest specimens being found in this region. Under certain conditions the growth in sheltered localities becomes excessive.

The results of an exposed position are seen in three or four ways. In addition to, (1) the mechanical action of the waves, there is (2) a very thorough aeration, and, (3) a constant renewal of the necessary salts. It is further probable that the character of the water itself is different on exposed coasts to that usually found in quiet regions.

It is evident therefore that *Ulva*, unlike some algæ which occur only in well-aerated water, finds a medium that is little disturbed by waves or currents congenial if not indeed preferable to rougher water. And it is possible that the large size of the fronds in sheltered localities is due not only to lack of wave-action, but to a response by the plant to the chemical character of the surrounding medium.

Salinity of Water.—This factor is doubtless of importance, and is one on which further data are desirable. At several places during the South Coast tour a luxuriant growth was found where 10 per cent. of fresh water was present, and at Southampton (Locality 5) the fresh water amounted to 20 per cent. On the other hand it is evident that *Ulva* can thrive where fresh water is practically absent, *e.g.*, on the semi-exposed parts of Clare Island and Durlston Bay. At Studland also where the growth in September was abundant and of larger size, about 1 per cent. only of fresh water was found. Information as to an optimum and maximum amount of fresh water for *Ulva* would be of interest.

Attachment.—When growing in a normal way *Ulva* is always attached by means of its basal disk. The plant may occur on rocks (saxicolous) or on other seaweeds (epiphytic), but it may also be found on almost any solid body. Attached plants can withstand considerable wave-action, and strength of current. A non-shifting substratum is therefore of the greatest importance, in connection with the presence of *Ulva* in a given district. A special form of attachment is that provided by mussels, but this subject is dealt with in the following section of this summary.

In certain localities *Ulva* is found in a floating but yet in a growing state, a type of growth which is well seen in Weymouth Backwater. In this case, plants or parts of plants have become detached from their moorings and owing to their not having been transported by currents, they are able to thrive and to form an "association" of floating *Ulva*. Other factors may be requisite for this form of growth, but the principal one concerned is clearly quiet water and lack of current; on an open coast such growth could not exist. It is improbable that spores ever give rise directly to free-floating plants; contact with a solid substance is usually necessary for sporelings to reach maturity. But it is conceivable that when an association of this type has once developed, it may continue to exist year after year without being replenished by young plants. Further data on this point are required.

Growth in Pure Water.—The pureness of the water with regard to nitrogenous pollution is a part of the enquiry that has received special attention at the hands of the Commission. The writer has been concerned with the investigation of the growth of *Ulva* in nature, whilst Professor Letts and Mr. Richards have been carrying out the more difficult task of experimenting with the plant in artificial cultures. Their results are of great interest, and it is to be hoped that the investigations will be continued till the nutrition of the plant is thoroughly understood.

With regard to the growth of the plant in nature, several of the localities examined show clearly that it occurs in water that is practically free from sewage pollution. On moderately exposed coasts a short but healthy growth is found, and in these localities (unless drainage-outfalls occur) the water is generally unpolluted. The character of the *Ulva*-growth in the rock pools of Clare Island (October, 1910) indicate with unmistakeable clearness that the plant is at home in pure water and that the growth is perfectly healthy. At Studland where the water is also free from sewage (see next paragraph) the growth is vigorous and abundant, and the plant finds the conditions without doubt favourable.

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* Throughout the investigations special attention was paid to the factors likely to be important in connection with the growth of *Ulva* in quantity. The ecological account therefore though a general one gives greater prominence to these factors.

Growth in Polluted Water.—Recent investigations by the Commission show that two types of pollution must be distinguished, namely: (*A*) natural; and (*B*) sewage pollution.

(*A*) Natural pollution is a form of contamination similar in its chemical nature to pollution by sewage, but produced by the decay of marine animal and vegetable matter. It takes place in nature to a considerable extent especially in quiet bays and other places where drift-seaweed accumulates. The pollution not only arises from the decay of the fronds, but also from the mud that is formed as a result of their decay. Except in land-locked localities such decomposition does not pollute the water to a very great extent, and the amount of ammoniacal nitrogen usually present is much less than at Belfast. At Studland where decaying weed collects, and where foul mud exists, a sample of water taken on a falling tide showed only one-tenth the quantity of ammoniacal nitrogen usually present in Belfast Lough. The albuminoid nitrogen figure was however rather high, and it is right to add that, although weed accumulates at Studland, the conditions are not by any means land-locked.

Where natural pollution is present *Ulva* frequently occurs in some quantity, and it is evident that the plant thrives in such localities. There appeared to be evidence to show that *Ulva* was more than usually plentiful and luxuriant where decaying weed is apt to accumulate, but the vigour of the plants in the pure water of Clare Island (October visit) and their abundance in the rock pools could hardly have been exceeded. When considering the growth of *Ulva* in naturally polluted regions, it should be remembered that positions where drift-seaweed collects, usually offer at the same time the sheltered water favourable for the growth of large fronds.

(*B*) Sewage-pollution, due to the discharge from drains and sewers, or to material of like nature, is found in the neighbourhood of towns on the open coasts, and on a larger scale in the mouths of rivers and estuaries. The effect on the marine vegetation of sewage-discharge on an exposed coast, is a relatively simple question. The problem in the case of an estuary or large sheet of calm water is more complicated, the effect of fresh water, quiet conditions, and the flat shore having to be taken in consideration.

In contrast to most marine algæ, *Ulva* not only grows in sewage-contaminated water but thrives to a remarkable degree. Its occurence on an open sea shore where marked and constant pollution is present, has not been observed sufficiently often to warrant definite conclusions; but in polluted estuaries its growth is so frequent that the characteristic features are well known. The plants grow very vigorously and sometimes produce fronds of an enormous size. The latter are of a deep green colour and readily distinguishable (especially when dry) from the pure water specimens. A difference in texture is also noticeable, the fronds being limp instead of crisp, though at the same time preserving their toughness.

As far as has been observed the polluted-estuary type of *Ulva* though producing a very large amount of vegetative growth during the season, shows little tendency to form spores; extended observations on the point are, however, needed.

Further remarks connected with the growth of the weed in estuaries occur in the following section.

2. Discussion as to Growth of Ulva in excessive Quantity.

Having considered the growth of *Ulva* in relation to the different ecological conditions we pass on to examine those factors which may be regarded as specially important with regard to its production in excessive quantity. At the outset it will be well to emphasise the necessity of distinguishing between an "abundant growth," and an "excessive growth" that is liable to give rise to a nuisance. The former implies the presence of a very large number of *Ulva*-plants especially in proportion to the size of the area on which they occur. The latter signifies an abundant growth extending over a large area.

For an abundant growth two factors are essential, viz., suitable anchorage, and quiet water. For a growth liable to produce a nuisance a third factor must exist in addition, viz., a very large area of suitable ground.

At Studland during the summer months an abundant growth of *Ulva* may be said to occur near the low-water line and in the shallow rock-pools. But in consequence of there being only a narrow strip of shore, the area of suitable ground is not extensive, and the *Ulva* is not produced in sufficient quantity to create a nuisance.* In Belfast Lough, on the other hand, not only is there anchorage and quiet water, but suitable ground amounting to many hundreds of acres; consequently there is a very extensive growth of weed, and a nuisance on its decay. It does not appear unfair to assume that, given a shore with the same ecological conditions as Studland, but with the width of the Belfast sloblands, a very extensive development of *Ulva* might occur. But, as a matter of fact, flat shores of great width, usually consist of sand or mud.

Turning for a moment from the physical factors to a consideration of the effect of the chemical nature of the water, Professor Letts has shown that the *Ulva* is stimulated by the presence of sewage. Though further experiments are required, it appears impossible to doubt that the plant grows much more rapidly in polluted than in pure water. But to obtain *Ulva* growth in any ordinary locality the physical conditions above referred to are absolutely essential, and are therefore of primary importance.† If sewage is present in addition the total "yield" is doubtless greater; and hence, in the case of a large area, the presence of pollution may be responsible for a material increase in the amount of nuisance. The experimental work being carried out by Professor Letts and Mr. Richards on the effect of fresh water and of sewage pollution on the rate of growth is clearly of great value in obtaining information on this point.

It has been shown above, that a rocky ground offering good anchorage is usually narrow; and, that a flat shore, though extensive, consists as a rule of sand or mud, a substratum which in itself offers no attachment for *Ulva*. What then are the conditions in the localities where *Ulva* occurs in excessive quantity, *i.e.*, where it finds both good anchorage, and a wide expanse of shore?

With the exception of the case of Weymouth (which is not yet properly understood, and where special conditions obtain) in all the districts examined an excessive growth was found to be associated with the presence of mussels on mud flats. The mooring provided by the byssus of the mussels is particularly secure. But the special importance of these molluscs lies in the fact that they colonize and provide anchorage on mud which would otherwise be bare or covered with fields of *Zostera*; and, owing to their vertical distribution agreeing with that of *Ulva*, the anchorage they supply is at the right level for growth of that weed.

This condition of affairs exists at Belfast, and it has been held for some time that if the mussels were removed the *Ulva*-growth would practically cease to exist. The different parts of Southampton Water that were investigated confirmed this conclusion in a striking way. The necessary attachment for the wide areas of *Ulva*-growth was invariably supplied by mussels; where mussels were found, *Ulva* occurred; and where there were no mussels there was no *Ulva*.

Under these circumstances the problem changes into an enquiry as to the factors which determine the presence of mussel-beds. There appears to be a general opinion amongst zoologists that mussels prefer a certain amount of fresh water, and that they are frequently, though not invariably, found in badly polluted districts. The subject needs further investigation. But whether sewage favours their development or not, it is beyond dispute that they are directly responsible for the large tracts of *Ulva* on the mud-flats.

The above remarks deal with the ecological factors connected with the excessive growth of *Ulva*; there remains for consideration the experimental and chemical work of Professor Letts and Mr. Richards. This is clearly of great importance, not only in connection with the *Ulva*-nuisance, but with the question of the purification of polluted water by green seaweeds, and the whole economy of the growth and decay of that type of marine vegetation.

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* Studland is referred to here and elsewhere, as being a locality where sewage pollution is absent.

† An exception exists in the case of very sheltered and landlocked localities where "associations" of loose floating *Ulva* occur (*see* Southampton, *loc.* 5). These, however, are of rare occurrence.

Their results will be published in full simultaneously with this report, but, without going into detail, the following important points established by them should be mentioned in connection with the ecological account given above.

1. In artificial cultures the growth is more rapid in mixtures of sewage and sea-water than in pure sea-water. In 1 per cent. sewage mixtures (the amount present in Belfast Lough) this increase is not marked, but with larger amounts of sewage, the growth during the months of July and August may be 3 or 4 times as great as that in pure sea-water. As was to be expected the stimulus of sewage is most powerful during the period of active growth.

2. The nitrogen-content of the weed varies in proportion to the amount of pollution present. This is the case in fronds grown in artificial cultures, and also in naturally grown fronds obtained from widely separated districts. In Belfast Lough the nitrogen-content varies from 3 to nearly 5 per cent, whereas the figure in September for Durlston Bay and Studland was 1·13 and 1·18 per cent respectively. This result is not surprising when the avidity of *Ulva* for ammonium compounds is considered (*v.* Letts, Appendix VI. to 5th Report). The *Ulva* occurring in polluted districts may therefore be regarded as a very highly-fed or "fattened" form (see Table on Composition of *Ulva* Fronds, p. 139).

3. The sulphur-content of *Ulva* also varies considerably, but the connection of the variation with the environment is not apparent. The figure for Belfast is 4 to 5·5 per cent., and the same high figure is maintained in the pure water of Durlston Bay and Studland. *Ulva* from Larne on the other hand showed only 2·16 per cent. The importance of the sulphur, lies in its possible connection with the sulphuretted hydrogen which is liberated on decay.

CONCLUSIONS.

Though many problems in the ecology of *Ulva* remain to be solved, the following conclusions appear to be justified from the investigations undertaken for the Commission.

Of the conditions necessary for the growth of *Ulva* in the littoral region, two may be singled out as of the very greatest importance:—(1) the absence of rough water; and (2) the presence of a substratum which affords a suitable anchorage for the plants. The attachment supplied by the "byssus" of mussels is found to be particularly secure. In muddy estuaries these molluscs are known to cover extensive areas of the foreshore, and when this is the case large stretches of ground suitable for the growth of *Ulva* may thus be provided.

Ulva is proved to be an alga that thrives in pure sea-water, and in polluted brackish water. Being a marine and not a fresh water organism, its growth in polluted estuaries is probably to be regarded as an adaptation. In sewage-contaminated water it absorbs large quantities of ammonia, and its tissues are found to contain a much larger proportion of nitrogen than fronds from pure sea-water in the corresponding season. The result of this excessive nourishment is seen in an increased rate of growth, the fronds being at the same time of a different texture and of a darker colour. But, as in other cases of over-fed plants, there is a tendency for spore-formation to remain in abeyance, and increase to take place by vegetative methods; the growth therefore may be considered as rank rather than healthy. It is possible that the highly-fed form of polluted localities is more obnoxious on decay than the normal form of pure water.

With regard to Belfast, in the opinion of the writer, *Ulva* will continue to occur there in quantity as long as the mussel-beds exist on the sloblands. And, as *Ulva* is not dependent on sewage, the purification of the Belfast effluent, though it would materially reduce the amount of growth, would not in his opinion suppress the weed, unless it should prove to have the effect of exterminating the mussels.

EXPLANATION OF PLATE.

The illustrations in the accompanying plate, which shows the structure and development of *Ulva Lactuca* L., are reproduced on a smaller scale from Thuret and Bornet's beautiful plates in their work entitled "*Etudes Phycologiques.*"

Fig. 1. Small plant of *Ulva*, half natural size. The discoloured tissue, produced by the formation and liberation of spores, is seen at the margin of the frond.

Fig. 2. Longitudinal section of the base of the frond, showing thickened portion due to filamentous prolongations from the peripheral cells. Magn. 80 diameters.

Fig. 3. Transverse section through the same. Magn. 80 diameters.

Fig. 4. Longitudinal section a short distance above the base of frond, at the point where the peripheral cells commence to form prolongations. Magn. 80 diameters.

Figs. 5–14 Magnified 165 diameters.

Fig. 5. Transverse section showing the two layers of cells typical of the genus *Ulva*. The chlorophyll forms a thin plate lying against the outer wall of the cells.

Fig. 6. Surface view of the same.

Fig. 7. Transverse section of frond a short time previous to the formation of spores.

Fig. 8. Surface view of same.

Fig. 9. Transverse section of frond showing formation of spores. The contents of the cells by successive divisions become transformed into spores.

Fig. 10. Section through discoloured portion which borders the frond of Fig. 1. A few cells contain spores which have not yet escaped, the remainder are empty.

Fig. 11. The same in surface view. The opening through which the spores have escaped is faintly visible in the centre of each cell.

Fig. 12. Spores with 4 cilia. The 4-ciliate type of zoospore of *Ulva* is termed by Thuret and Bornet "macrozoospore."

Figs. 13 and 14. Germination of spores.

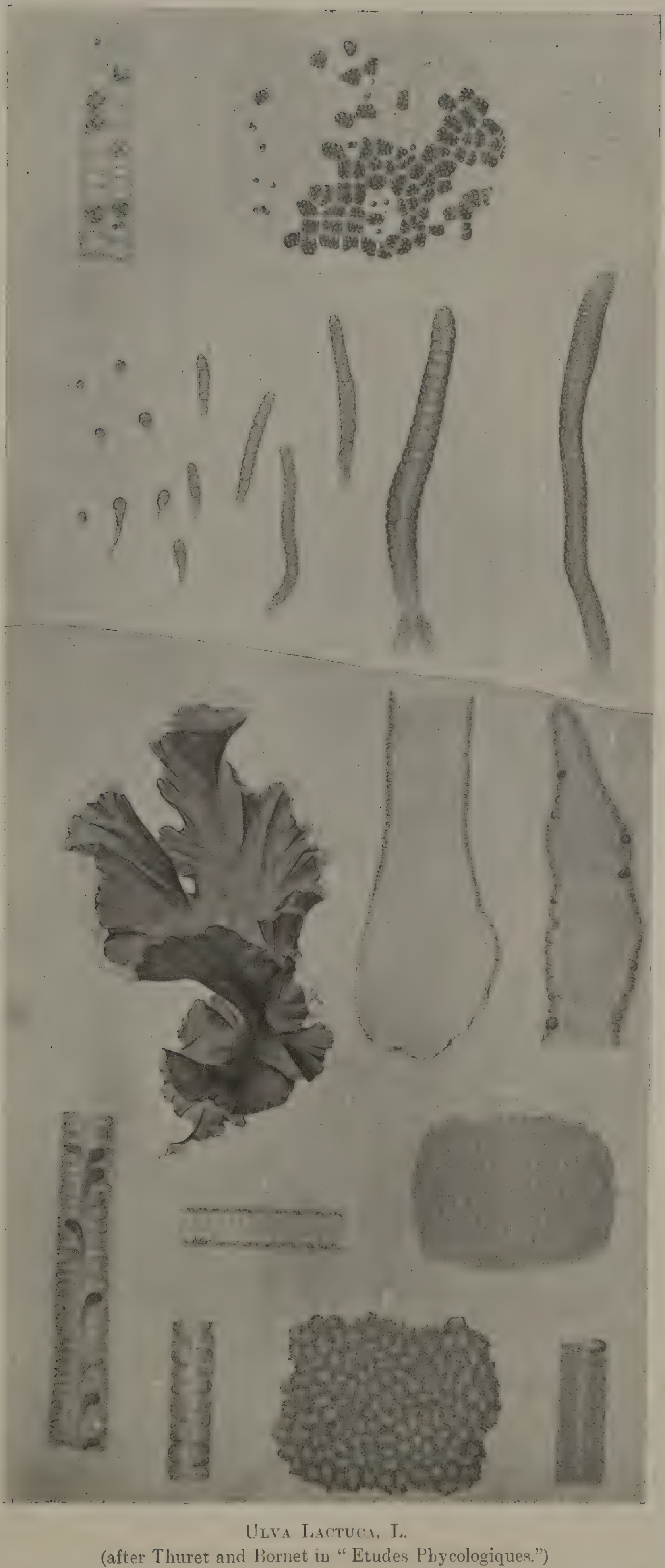
A detailed account of the spore-formation and liberation in *Ulva* will be found in the work from which the accompanying plates are taken. A more recent account is given by Schiller in a paper published in 1907, where several new points are brought to light. Such microscopic details of structure, although important, are not necessary for the present report; but in connection with the Belfast cultural experiments, Thuret and Bornet's account of spore-discharge is of sufficient interest to be referred to here.

The following is a free translation of the passage alluded to.

"It has often happened while we have been collecting on calm days at the sea-side, that we have been present during the liberation of zoospores. The phenomenon is to be seen in shallow pools, where the water gets warm, becomes concentrated, and assumes an oily appearance. It appears as if the fronds almost melted away into spores. Thick green clouds diffuse in the water and re-assemble on the surface in an opaque layer.

"The change in density produced by the return of the tide, or accidental movements imparted to the water, appears to determine this sudden liberation of spores. Nothing occurs in the rock-pools that may not be seen if *Ulva* is placed in tanks for experimental purposes, but the phenomena are on a very much larger scale.

"If a glass vessel containing zoospores is placed near a window, it often happens that the spores form at the near side and at the surface of the water, a distinct green zone, the maximum intensity of which is at the spot nearest the window. From each side of this point the colouration fades. A little later the coloured zone spreads, and disposes itself in dichotomous branches, or arranges itself in more or less symmetrical reticulated figures. The interposition of a screen causes the prompt disappearance of these figures, but they are reformed with more or less marked modification if the screen is removed. In a dish exposed to full diffused light, the zoospores distribute themselves equally at the surface of the liquid." After a time the zoospores recede from the light and proceed to germinate.



Ulva Lactuca, L.
(after Thuret and Bornet in " Etudes Phycologiques.")

APPENDIX V.

EXPERIMENTS UPON THE DESTRUCTION OF *ULVA LATISSIMA*, AND UPON THE PREVENTION OF ITS GROWTH BY THE REMOVAL OF MUSSELS. — REPORT TO THE COMMISSION BY C. C. FRYE AND G. B. KERSHAW.

October, 1910.

The examination of Belfast Lough in September, 1909, showed that the great growth of *ulva latissima* and other varieties of green seaweed occurred on the County Down slobland, and, further, that such growth was more or less confined to certain limited areas.

We estimated that these densely overgrown areas amounted, in the aggregate, to not much more than about 500 acres.

Since the whole of this area is "left dry" by ebb of the tides for the larger portion of the day, it seemed not impracticable of accomplishment either to destroy the weed where it grew, or to remove bodily the mussels which afford it anchorage.

I.—Destruction by Chemicals.

The experiments in the destruction of *ulva* began on September 17th, 1909, with the distribution of 1 cwt. of well-crushed copper sulphate crystals, at low water, over a selected and marked area of 1 acre of slobland on the outer portion of the Tillysburn bank. This area was almost entirely covered with large fronds of *ulva* attached to mussels.

The copper sulphate was carried in pails and thrown by hand. The time occupied was about fifteen minutes, three persons being employed.

The only noticeable effect at the time the copper sulphate was applied was upon the small creatures in the pools of water.

The area was not visited again until September 22nd, when the Commissioners themselves saw it.

By this time almost the whole of the green seaweed on it had turned brown, and was breaking away from its anchorage. The salted plot could be distinguished from the surrounding slob a quarter of a mile away. Many mussels were observed to be dead, and there was a strong smell of dead mussel on the plot; but most of the mussel shells were empty, the contents having been eaten by gulls.

The plot was visited periodically until October 1st. Up to this time it remained brown in appearance, and the dead fronds of *ulva* having been gradually removed by the tides, the mussels were exposed to view. Further, it was noticed particularly that much of the black mud previously lying under, and no doubt protected by, the *ulva* had now disappeared, clean sand showing in all the channels between the mussel hummocks.

On November 9th, 1909, when the next inspection took place, the plot could still be distinguished at a distance, but now much loose *ulva* had been washed on to it, and some *ulva* was also growing attached to mussels. The impression we obtained was that, the season being suitable, the plot would again be covered with growth in a few weeks, that is to say, about two months after the application of the copper sulphate.

On September 28th, at the suggestion of Colonel Harding, a second experiment was tried, the main object of this being to see if hand distribution of copper sulphate could be dispensed with.

In this case eight sacks containing ordinary crystals of copper sulphate were placed in marked positions on the muddy Connswater slob. Each sack contained 56 lbs. of the salt.

The result was disappointing; only the *ulva* close to the sacks and in the slob channels leading to and from the sacks being appreciably affected.

The experiment would probably have been more successful if a less muddy area had been selected, for the sacks sank considerably into the mud, and this made the rate of solution of the copper sulphate very slow indeed.

In order to see if cheaper and non-poisonous substances could be successfully employed for the purpose of destroying *ulva*, four 1-acre plots were selected on the Tillysburn bank and treated separately with 1 cwt. of each of the following substances:—

(1) Strong sulphuric acid (November 10th, 1909).
(2) Bleaching powder (November 10th, 1909).
(3) Caustic soda (November 11th, 1909).
(4) Quick lime (November 12th, 1909).

The sulphuric acid (B.O.V.) and the caustic soda (in the form of a strong solution), were distributed by means of small watering cans; the bleaching powder and quick lime were thrown on by hand.

In no case was the effect upon the *ulva* striking. The sulphuric acid burned through the *ulva* fronds where it fell, causing merely local destruction; the bleaching powder killed many mussels, but had only a very slight effect on the *ulva;* the caustic soda solution and the quick lime had no very great effect upon either the *ulva* or the mussels.

The marked effect produced by the copper sulphate in the first experiment led the Commission to determine that it would be worth while to repeat this on a larger scale, and at a time when the young *ulva* shoots were beginning to show on the banks.

Accordingly, one of us proceeded to Belfast in May, 1910, and with the assistance of twenty-two men distributed, by hand, 3 tons of crushed copper sulphate over an area of about 37 acres of Connswater slob. This area is marked I. on the plan given in connection with the Commission's report.

The muddy slob fringed by the Silver Stream, the Connswater river and the Musgrave channel was selected for treatment on this occasion.

The copper sulphate was brought over the centre of the area by barge at high water, and, having been roughly crushed on board, was distributed by hand from pails.

Notwithstanding the depth and softness of the mud on this part of the bank, the whole operation was carried out in two days (May 5th and 6th, 1910), the time taken up by the actual "salting" being about eight hours.

It will be seen that the quantity of copper sulphate used on the area was equivalent to about 182 lbs. per acre.

The date of the experiment was selected under the advice of Professor Letts, who had made observations on the condition of the banks throughout the winter.

At the time of "salting," the mussel banks were fairly well covered with both large and small fronds of *ulva*. In the pools between the mussel hummocks most of the weed was *monostroma grevillii* (*see* Mr. Cotton's report), but "*May fog*" was also plentiful. On the Sydenham end of the area there was a good deal of *zostera marina*.

The area was inspected on May 9th, *i.e.*, three and four days after the application of the copper sulphate.

The most marked effect was upon the *monostroma* and the "*May fog*," almost the whole of which was either dead or dying. The *zostera marina* and the *ulva* were also showing signs of having been damaged, but not to the same extent as the *monostroma*. Many mussels, say 20 or 25 per cent. of the whole, had been killed, and on some parts of the bank a considerable smell arose from them.

A large number of the open mussel shells were empty, the contents having evidently been eaten by gulls. No dead gulls were observed, but on May 7th two or three large herring gulls were observed on the mud in somewhat listless attitudes, and disinclined to fly when attempts were made to disturb them.

After May 9th, 1910, we ourselves had no opportunity of observing the condition of the treated area. On June 3rd, 1910, however, in company with some members of the City Council, Mr. Cutler, the City Surveyor, inspected it. He reported that it looked like a desert, and said, further, that his Committee were so pleased with the apparent success of the operation that they had instructed him to purchase another 3 or 4 tons of copper sulphate, for the purpose of treating other portions of the slob.

On July 29th, 1910, Professor Letts and Mr. E. H. Richards went carefully over the area, and made the following report to the Commission:—

"When we last saw this (area "salted" on May 6th and 7th, 1910) about two months ago, there was scarcely any *ulva*, but now it was quite green and covered to a depth of 2 to 3 inches with that seaweed, mixed with a good deal of '*May fog*.' As far as we could observe, most of these seaweeds were unattached to mussels and had drifted to this place.

"A very remarkable change had occurred in the surface of the ground here, which before the 'salting' was so soft that at times one would be up to the knees when walking through it, but was now fairly hard, and one seldom sank more than a few inches.

"Also a great deal of 'sea grass' (*zostera marina*) had sprung up, where there had been none before.

"It ought, however, to be noted that there were plenty of living mussles on this patch, and that undoubtedly some were attached to *ulva*."

This large scale experiment with copper sulphate thus entirely confirmed the results obtained in September, 1909, on the 1-acre plot.

The following conclusions are, we think, justified by these experiments:—

(1) That copper sulphate crystals, when carefully distributed in the proportion of about 1½ cwts. per acre over areas of slob covered with *ulva latissima* and other similar seaweeds, will destroy such weed almost completely in the course of about a week.

(2) That this effect is only a temporary one, lasting about two months.

(3) That the application of copper sulphate in destroying weeds and killing many mussels assists the natural cleansing of the banks by the tides to a very marked extent.

(4) That some nuisance from smell through the decomposition of mussels arises shortly after the application of the copper sulphate, but that beyond this, so far as the observations go, no disadvantage is likely to be caused.

The results of Mr. Cutler's experiments with copper sulphate are given in a separate report by him (Appendix VI.).

II.—Removal of Mussels.

The experiment upon the removal of mussels was begun on September 30th, 1909.

A small portion, about half an acre, of the outer Tillysburn bank, fairly well covered with mussel hummocks and growing *ulva*, was selected and marked at low water on September 29th.

On September 30th, as soon as the morning tide had receded sufficiently, this area was roughly cleared of mussels and *ulva* by means of rakes and spades. The loose mussels and the *ulva* were dumped into the channel of the Tillysburn river near by.

The operation was more or less satisfactorily performed in about three hours, eight men being employed.

After the removal of the mussels and the *Ulva* the area presented a uniform grey-black appearance, being coated with black mud which had been disturbed from under the mussel hummocks.

By the next day a striking change had taken place either through the scour of the tides, which are slight on this part of the bank, or through the oxidation of the mud, or, what is probably more correct, through both causes together.

The area now presented a surface of clean shining sand, dotted here and there with isolated mussels.

On November 10th, 1909, the plot bore much the same appearance, its surface being composed of clean sand.

There appeared to be a greater number of isolated mussels, however, at this time, and small fronds of *ulva* were attached to some of these.

In May, 1910, the plot was again inspected. A considerable number of full-grown mussels had been washed on to it during the winter months, and *ulva* or *monostroma* fronds were attached to a fair percentage of them, but it still presented a different appearance to the surrounding slob and could be distinguished at a considerable distance.

It will be seen that the effect of the removal of mussels from this small area of slob lasted for at least eight months, notwithstanding the fact that the area was surrounded by densely-packed mussel banks.

On the other hand, it must be specially noted that the observations relate to the winter months only. (*See* note).

COLIN C. FRYE.
G. BERTRAM KERSHAW.

October, 1910.

Note.—The Commission thought it desirable that this experiment should be repeated on a much larger scale. On being informed of this view the Belfast City Corporation undertook the work. The results of this larger experiment are given in Mr. Cutler's report (Appendix VI).

APPENDIX VI.

To the SECRETARY of the ROYAL COMMISSION on SEWAGE DISPOSAL.

SIR,

As requested, I have pleasure in reporting upon the results produced upon the foreshore of the Belfast Lough, in the County of Down, by treatment with sulphate of copper and by removal of mussels.

TREATMENT BY SULPHATE OF COPPER.

Between 3rd and 5th May of this year, under the direction of Mr. Colin C. Frye, 3 tons of sulphate of copper, broken small and partly powdered, were sprinkled over an area of 37 acres of the foreshore (marked No. 1 on Plan), which was densely covered with mussels, and where the weed known as ulva latissima, and other weeds of the same family, had commenced their annual growth. Within about four days the weed on the area treated was in a decaying condition and large quantities of mussels had been killed. Up to the beginning of July the area above mentioned was practically sterile so far as the growth of the weed was concerned, but since that time the weed seems to have overcome the effects of the copper, and at present, where the mussels were not destroyed, the weed is as luxurious and heavy in its growth as on portions of the shore untreated.

Up to the month of June the copper treatment appeared so effective that it was decided to treat other areas where the weed had become very luxuriant and completely blanketted the mussels.

Between June 8th and July 26th nine tons of copper sulphate were spread on 86 acres of the foreshore (marked 2 to 4 on plan), and within three or four days of the treatment the whole of the weed and large quantities of mussels were killed on each of the areas dealt with.

The effects of the copper spread on the areas treated since June 8th, except where mussels were killed, appear now to have been overcome, as the weed is again growing and is in a flourishing condition.

It is interesting to notice that the weed, shells and organic mud have to a great extent disappeared where the mussels have been killed, leaving clean foreshore, and that the areas which have been treated are now easily accessible, whereas formerly owing to the thickness of the mud they were only traversed with great difficulty and labour.

The destruction of the mussels by the sulphate of copper on the area treated on May 5th does not appear to have been so great as on the areas since treated, and the reason may be that the mussel-beds were thicker, or that the quantity of copper used per acre since June 8th has been greater.

The average cost of treatment with sulphate of copper, including labour, amounts to £2 11s. per acre.

MUSSEL CLEARING.

Early in May it was decided, for experimental purposes, to try the effect of clearing the mussels from about 100 acres of the County Down Foreshore, and on the 28th May gangs of men were started to clear mussels from certain areas and load them into barges and deposit them on certain slobland over which the Harbour Commissioners were forming an embankment.

Since the commencement of the clearing, operations have been continuously carried on, but latterly the mussels have been buried in trenches in situ, as arrangements could not be made to incorporate them in the Harbour Commissioners' Bank as formerly.

Up to the present time an area of 63 acres of the foreshore has been cleared of mussels, with the result that the area referred to has practically ceased to be a nursery for growing weed, and that the organic mud has disappeared.

The cost of mussel clearing has amounted to £14 10s. per acre.

GENERAL OBSERVATIONS.

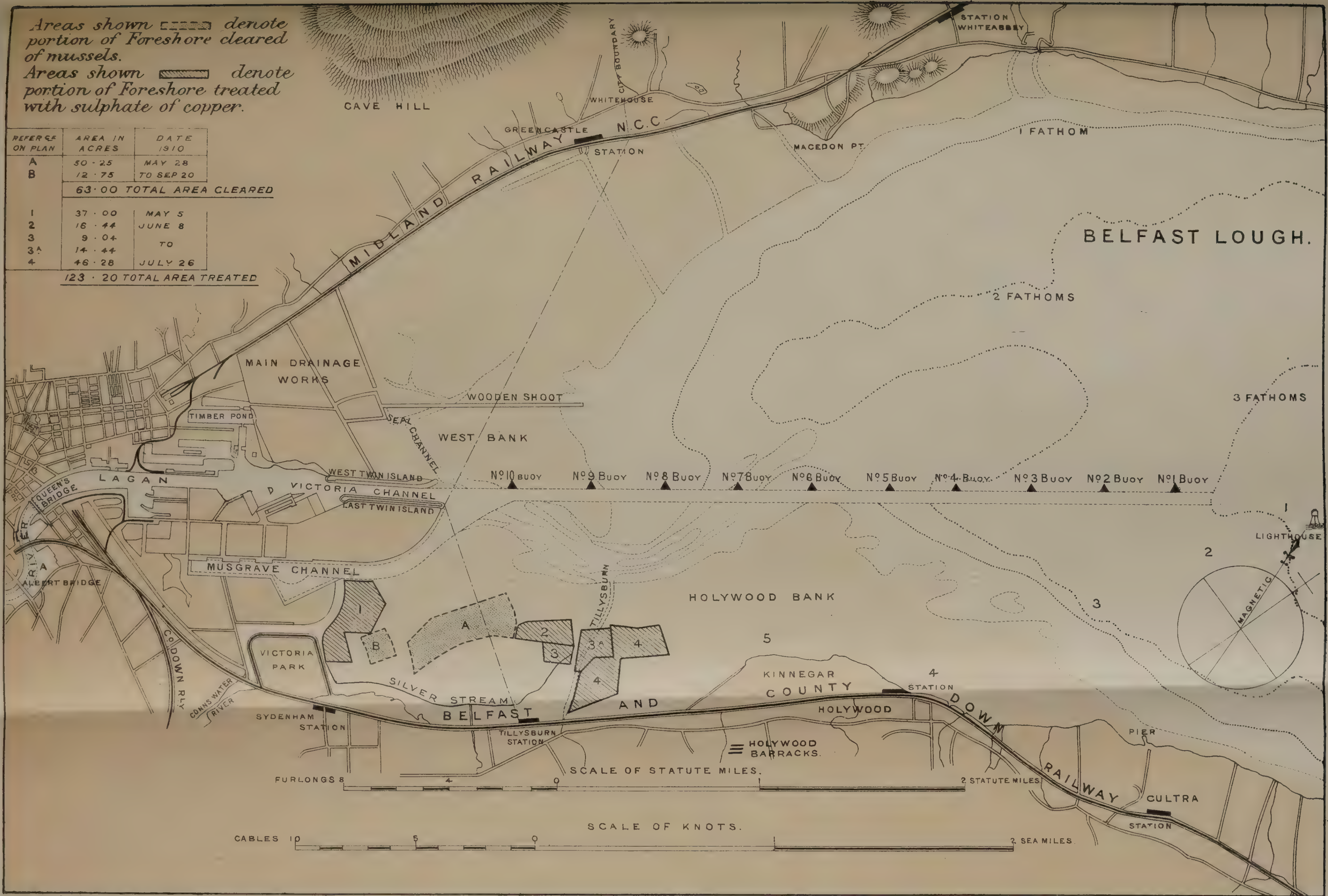
Both the spreading of the sulphate of copper and the clearing of mussels appear to have been remarkably efficient in reducing the growth of the weed, as the quantities of weed washed up on the foreshore and the smell from the decay of same have been materially less than in previous years. So far as the smell is concerned, complaints from residents on the foreshore have been very few, and the improved condition has been generally recognised.

Where the mussels have been destroyed, treatment by sulphate of copper has been just as effective as clearing, but with the doses used several applications would be necessary, as considerable quantities of mussels have survived the process on all the areas treated.

From the experiments above referred to, I have come to the conclusion that the mussel-beds on the County Down Foreshore are a great nursery for the production of ulva, and that the weed growth cannot be prevented unless the mussels are removed or destroyed.

I remain, Sir,
Your obedient Servant,
HENRY A. CUTLER,
City Surveyor.

September, 1910.


Areas shown ▨ *denote portion of Foreshore cleared of mussels.*
Areas shown ▨ *denote portion of Foreshore treated with sulphate of copper.*

REFERCE ON PLAN	AREA IN ACRES	DATE 1910
A	50·25	MAY 28
B	12·75	TO SEP 20
	63·00 TOTAL AREA CLEARED	
1	37·00	MAY 5
2	16·44	JUNE 8
3	9·04	TO
3A	14·44	
4	46·28	JULY 26
	123·20 TOTAL AREA TREATED	

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ROYAL COMMISSION ON SEWAGE DISPOSAL.

SEVENTH REPORT

OF

THE COMMISSIONERS

APPOINTED TO INQUIRE AND REPORT WHAT METHODS OF

Treating and Disposing of Sewage

(Including any Liquid from any Factory or Manufacturing Process)

MAY PROPERLY BE ADOPTED.

VOL. III.—APPENDICES.—PART II.

Minutes of Evidence with regard to the Treatment of Trade Effluents.

Reports by the Officers of the Commission upon the Preliminary Treatment of Sewage in Slate Beds.

Presented to both Houses of Parliament by Command of His Majesty.

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NOTE.—The Commission have thought it desirable to publish, at this stage, the further evidence which they have taken with regard to the treatment of trade effluents, but they will defer reporting on this subject until their investigations in the matter are completed.

MINUTES OF EVIDENCE

TAKEN BEFORE THE

ROYAL COMMISSION

APPOINTED TO

Inquire and Report: First, what method or methods of treating and disposing of Sewage (including any Liquid from any Factory, or Manufacturing Process) may properly be adopted consistently with due regard for the requirements of the existing Law, for the protection of Public Health, and for the economical and efficient discharge of the duties of Local Authorities; and, if more than one method may be so adopted, by what rules, in relation to the nature or volume of Sewage, or the Population to be served, or other varying circumstances or requirements, should the particular Method of Treatment and Disposal to be adopted, be determined; and, secondly, to make any Recommendations which may be deemed desirable with reference to the Treatment and Disposal of Sewage.

EIGHTY-SEVENTH DAY.

Tuesday, 26th January, 1909.

PRESENT:

Colonel T. W. Harding, J.P., D.L. (*in the Chair*).
Sir William Ramsay, K.C.B., F.R.S.
Mr. T. J. Stafford, C.B., F.R.C.S.I.
Mr. R. A. Tatton, M.Inst.C.E.
Mr. F. J. Willis (*Secretary*).

ALSO PRESENT:

Dr. A. C. Houston.
Mr. C. C. Frye.
Mr. G. B. Kershaw.

Mr. Harold Frederic Atter, Clerk and Solicitor to the West Riding of Yorkshire Rivers Board; and Dr. H. Maclean Wilson, Chief Inspector of the West Riding Rivers Board, called in.

Mr. Harold Frederic Atter examined.

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27165 (*Chairman.*) In the regrettable absence of Lord Iddesleigh, who is, I am sorry to say, laid up, it falls to my lot to question you. You are, I believe, Clerk and Solicitor to the West Riding of Yorkshire Rivers Board?—I am, Sir.

27166. You have prepared for our information an exceedingly clear and reasonably short document, which puts very clearly the points upon which your Board think that legislation might help you?—I have prepared a summary, Sir.

27167. I do not propose to ask you to read this document, of which we all have a copy, and which can be embodied in your evidence. Therefore, we propose to take it as read?—If you please, Sir.

(*The Witness handed in the following Statement.*)

New Sources of Pollution.

The law should be amended so as to make it possible to prevent or to regulate the establishment of new sources of pollution. It would not be unreasonable to require every person who intends to carry on any business from which liquid refuse of any kind might be discharged into a stream to give notice of his intention to the sanitary authority and to the Rivers Board of the district, specifying what steps he proposes to take to prevent such liquid refuse polluting the stream. Either the sanitary authority or the Rivers Board should have power to disapprove the proposals, subject to appeal to the Central Authority. A person failing to give notice or commencing to discharge liquid refuse after his proposals have been disapproved should incur a substantial forfeiture and a daily penalty; recoverable either in the County Court or a Court of Summary Jurisdiction. It would be necessary to provide that the decision of the Sanitary Authority, the Rivers Board, and the Central Authority should be given within a limited time so as to avoid undue delay.

Some authorities have special powers for dealing with new pollutions.

[*See* Lee Conservancy Act, 1868, Sec. 91; Thames Conservancy Act, 1894, Sec. 93; and Middlesex County Council Acts, 1898, Sec. 12, and 1906, Sec. 10; and cf. Alkali Works Regulation Act, 1881, Sec. 12.]

Abuse of Purification Works.

There should be a summary method of dealing with cases where purification works have been provided and are not properly used. A substantial forfeiture, recoverable either in the County Court or a Court of Summary Jurisdiction, would probably be most effective.

It would strengthen the hands of sanitary authorities if traders were expressly made responsible for all polluting discharges from their purification works, as the excuse usually offered is that the man in charge of the works was careless or was disobeying instructions in allowing pollution to occur.

Short Tenancies.

The person responsible for causing or permitting liquid refuse to pollute a stream is usually the occupier and not the owner of the premises whence it proceeds. Where a mill is let on a short tenancy it does not seem equitable to put the tenant to the cost of providing expensive purification plant. It is suggested that the owner of premises let for less than a certain specified term, should be under the obligation to provide efficient means for

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enabling the liquid refuse from the premises to be so dealt with as to prevent pollution.

Liquid Refuse dealt with by Contractor.

In many cases manufacturers dispose of their refuse to an independent contractor, who makes his profit by recovering by-products. The actual terms of the agreements between the manufacturers and the contractors vary greatly, and it is often difficult to say with any degree of certainty who is responsible for the pollution caused by the discharge of imperfectly purified liquids.

The Rivers Board suggest that the trader should be responsible, at any rate when the by-product plant is on his premises, unless he produces to the Rivers Board a written agreement in force between himself and the contractor, whereby the contractor specifically agrees to deal with the liquid refuse so as to prevent pollution. In the latter case the contractor should be made responsible.

Ochre Water.

Many of the streams in the West Riding are grossly polluted by what is locally called " Ochre Water." This is water containing iron and acid. It is drained from coal or ganister mines, and discharged into streams "in the same condition as that in which it has been drained or raised from such mines," and, therefore, no offence against the 1876 Act is committed, however great may be the pollution of the stream. This ochre water is most injurious to boilers, condensers, etc., it eats away iron plates, and no fish can live in the streams which are polluted by it.

Samples.

Under the Act of 1876 there is no express power to take samples, and under the West Riding of Yorkshire Rivers Act, 1894, Sec. 15, the power to take samples is limited to those taken (*a*) in relation to proceedings under that Act; and (*b*) at the point where the effluent passes into the stream. There are many cases where it is impossible to take a sample at the exact point where it discharges into a stream. The outlet may be submerged, or the stream into which it discharges may be, and very often is, culverted. The inspectors of the Sanitary Authority should have power to take samples wherever they can be obtained, and, if they cannot be obtained in any other way, even to open the ground and uncover drains for the purpose, reinstating them of course when the samples have been taken.

The following precedents may be referred to: Alkali Works Regulation Act, 1881, Secs. 16 and 17; Thames Conservancy Act, 1894, Sec. 98; and Middlesex County Council Act, 1898, Secs. 11 and 14, as extended by Middlesex County Council Act, 1906, Sec. 7.

Discharges by Joint Outlet.

In many cases two or more manufacturers discharge their trade liquids through one outfall or drain into a stream. In such cases it is difficult to prove who is responsible for the pollution of the stream caused by the discharge from the common drain or outfall. At the time a sample is taken only one of the mills may be sending forth polluting liquids.

A sanitary authority should have power to take samples of the liquid discharged from all or any of the premises into the drain, and to take proceedings against the occupiers jointly or individually.

[Cf. Alkali Works Regulation Act, 1881, Sec. 28, and Public Health Act, 1875, Sec. 255.]

Procedure.

(a) *Jurisdiction of Local Government Board.*

Under Sec. 6 of the Rivers Pollution Prevention Act, 1876, proceedings in respect of offences against Part III. of that Act can only be taken with the consent of the Local Government Board. The jurisdiction of the Local Government Board in these matters should be clearly defined, and they should not be asked to decide the merits of defences which are purely legal. Their jurisdiction should be limited to deciding whether the liquids discharged are of a polluting character and whether means for rendering them harmless are reasonably practicable and available under the circumstances of each case, having regard to the probable cost and to the effect upon the industry of trade. If this suggestion is not considered practicable, it might be provided that if the Local Government Board refuse their consent in any case they shall state the reasons for their refusal, and if any of those reasons involve a question of law the Rivers Board may appeal to the Court of Appeal.

(b) *Time-limit for Consent or Refusal.*

Following the precedent of Sec. 6 (4) of the Mersey and Irwell Joint Committee Act, 1892, the Local Government Board should be required to give their decision within three months from the date when the sanitary authority applied for their consent. Very great delay has been caused in the West Riding by the time which the Local Government Board has taken in dealing with applications for consent to take proceedings against manufacturers.

(c) *Means Available.*

The third paragraph of Sec. 6 of the Act of 1876 provides that the Local Government Board shall not give their consent to proceedings unless they are satisfied (*inter alia*) "that means for rendering harmless the poisonous noxious or polluting liquids . . . are reasonably practicable and available under all the circumstances of the case." It is doubtful whether the fact that the local authority has a sewer into which they are prepared to receive the polluting liquids from the factory is a means for rendering harmless the polluting liquids.

(d) *Two Months' Notice.*

After having obtained the consent of the Local Government Board it is necessary to give two months' notice of the intention of the sanitary authority to take proceedings. It is submitted that this two months' notice is unnecessary, and merely increases the delay incident to proceedings under Part III. of the 1876 Act. In practice the Rivers Board have not found that the manufacturer takes advantage of the two months, which are given presumably to afford him an opportunity of constructing purification works.

(e) *Proceedings against Firm.*

A sanitary authority should have power in all cases to take proceedings in the firm's name against persons carrying on business in partnership.

[*See* Alkali Works Regulation Act, 1881, Sec. 23; and Factory and Workshop Act, 1901, Sec. 146; and cf. County Court Rules, 1903, Order III., Rules 14 and 17.]

(f) *Orders to Bind Successors.*

An Order made under Sec. 10 of the 1876 Act only binds the person or company against whom it is made. If the business changes hands the whole procedure of the 1876 Act must be again followed before an Order can be obtained against the new occupiers of the premises, even though the same trade has been carried on continuously in the same way and the whole business has been taken over as a going concern from the previous occupiers.

[Cf. Thames Conservancy Act, 1894, Sec. 95, and Middlesex County Council Act, 1898, Sec. 15.]

Jurisdiction of Rivers Board.

Sec. 20 defines the word " stream " as including rivers, streams, canals, lakes and watercourses with certain exceptions. The Local Government Act, 1888, Sec. 14, provides that the Local Government Board by a Provisional Order may constitute a Joint Committee or other body representing all the administrative counties through or by which a river or any specified portion of a river or any tributary thereof passes, and may confer on such committee or body all of the powers of a sanitary authority under the Rivers Pollution Prevention Act, 1876. The Orders made by the Local Government Board with reference to the West Riding of Yorkshire Rivers Board, the Mersey and Irwell Joint Committee, and the River Ribble Joint Committee only give those bodies power to enforce the provisions of the Act with regard to " so much of every river or tributary thereof as passes through or by their respective districts." It has been argued in some cases, and the Local Government Board have taken the view, that this excludes canals from the jurisdiction of the Rivers Board. It should be made clear that the Rivers Board have full jurisdiction in their district over every stream as defined by the 1876 Act.

The definition of " stream " should also be amended so as to define with greater accuracy what is the limit of " tidal waters."

The Rivers Board should also have power to enforce the removal from the bed of a stream of the solid matter which has been deposited from trade liquids discharged into it. At present the Rivers Board can only obtain an Order preventing further pollution. They have no power to compel a person who has polluted the stream to abate the nuisance already caused.

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27168. Under Sec. 6 of the Rivers Pollution Prevention Act, 1876, proceedings in respect of offences against Part III. of that Act can only be taken with the consent of the Local Government Board ?—That is so, Sir.

27169. Sec. 6 of the Mersey and Irwell Joint Committee Act, 1892, provides that the Local Government Board shall give their decision within three months from the date when the sanitary authority applied for their consent. Is not that so ?—Sec. 6, Subsection 4.

27170. But in your case there is no fixed limit within which you are to receive an answer from the Local Government Board ?—No limit at all, Sir.

27171. In practice, do you find that you get from the Local Government Board decisions within reasonable time, or within something like the time provided in the Mersey and Irwell Acts ?—In all cases in which application was made for consent to take proceedings, up to and including October, 1907, we had no difficulty whatever There were ninety-five applications, and in thirty-two of these consent was given within three months, and in thirty-six it was given within four months after the date of the application; that is two-thirds, substantially within the period. But after October, 1907, we have, I think, very great cause to complain of the inaction of the Local Government Board. There are now pending twenty-seven cases where application has been made to the Local Government Board for their consent to take proceedings. Nineteen of those cases were sent to them so long ago as January, 1908—a year ago. We have not received from the Local Government Board any intimation of what they intend to do; we have merely received a printed acknowledgment of the receipt of the applications. Now, Sir, in July my Board instructed me to write to the Local Government Board, and to ask them what they proposed to do with regard to those applications, pointing out the delay which was being caused in the work of the Rivers Board. In September I got a reply from the Local Government Board saying "the Board have not at present arrived at a decision in this matter." In October I wrote again on the instructions of the Rivers Board, pointing out that their work was being very much delayed. I explained that many manufacturers had been threatened with proceedings, and as a result of those threats a considerable number of them had started to construct purification works. We had said to them: "Either you must give us a promise to do this, or else we shall take proceedings." Many of them gave us a promise and we did not take proceedings. They have now constructed works, but those who refused to do anything are in a far better position as they have saved their money. They see we cannot take proceedings, and they are rather laughing at their co-manufacturers. Not only that but there is a very general feeling abroad in the West Riding that the Rivers Board have no power to do anything with regard to trade refuse and the manufacturers are I am afraid, acting in accordance with those views. I wrote a very strong letter to the Local Government Board on October 16th and again on November 16th, and having no reply beyond a printed acknowledgment I wrote again on December 3rd saying: "I shall be glad to have a reply in time to be considered at the Committee meeting to be held on Friday next, December 11th." There was no reply to that and we have heard nothing more from the Local Government Board.

27172. And the effect of this delay, you say, is very serious in connection with the work of your board ?—It is most serious. Probably Dr. Wilson will be able to tell you better than I can the effect on the work of the board, because he naturally goes up and down the county and has more direct intercourse with the manufacturers than I do; but in my own experience I can see a very great change in their attitude. This is going to set back the work of the Rivers Board for years, because manufacturers had begun to understand that when the Rivers Board required a thing to be done, and it was not unreasonable, they would have to do it, but now they see that we cannot enforce our requirements.

27173. Have you reason to think that any of your manufacturers or manufacturers' associations have approached the Local Government Board in this matter ?—I know they have, Sir, because each of the manufacturers' associations concerned have sent me a copy of a petition they presented. A deputation from the Batley Chamber of Commerce, the Dewsbury Chamber of Commerce, the Dewsbury Corporation, and the West Riding Millowners' and Occupiers' Association waited upon the President of the Local Government Board on December 23rd, 1907, and the main object of their interview was to urge upon him the desirability of introducing legislation on the lines of the third Report of your Commission. That is, if I may say so, an object with which we, the Rivers Board, have every sympathy. They went further and urged that, pending the introduction of legislation, the Local Government Board should not give consent to proceedings being taken against any manufacturers in Yorkshire.

27174. Then the cause of the delay would appear to be that legislation is proposed ?—That appears to be the only reason.

27175. And that it is considered inadvisable to allow you to take action pending such proposed legislation ?—That is the only reason, Sir, that we can see.

27176. There is something, of course, to be said for that view ?—That is so, Sir, if I may say so with respect, up to a certain limit. What the Rivers Board feel is this: that if legislation is to be introduced in the near future it would be a pity to alter the status of individual manufacturers in the meantime, but if it is a mere pious hope on the part of those responsible at the Local Government Board that legislation will be introduced some time before the millennium, we think it unreasonable to practically repeal the existing law until that hope matures. There should be some limit, we think.

27177. And obviously your board considers that the legislation which has been suggested is urgently required ?—I think I may say that they do, Sir; that that is their opinion.

27178. (*Sir William Ramsay.*) I think the President of the Local Government Board anticipated that he would be able to introduce a Bill in May, 1908 ?—Well, Sir, on October 30th, 1907, I believe you yourself were a member of a deputation from the British Science Guild that waited upon him. He said he hoped to bring in a Bill next session. He also said—or at least is reported to have said—that manufacturers should be persuaded, if possible, but if not amenable to persuasion should be compelled to deal with their effluents in such a manner as to make them innocuous, and that in many cases this might be done, not at any great cost to themselves, but actually to their own profit.

27179. Yes, I remember.—And then again, Sir, in reply to various questions which have been put in Parliament from time to time, he has said he hoped to bring in legislation last session.

27180. (*Chairman.*) In the case of new works about to be started, what is the course of procedure that your board thinks ought to be followed ?—May I say, Sir, that that is not a matter which has been actually considered by the Rivers Board. These suggestions that I have made are suggestions which Dr. Wilson and I have made more or less on our own account, and they have been submitted to the chairman, but I cannot say that that is the deliberate opinion of the Rivers Board as a whole, because that proposition has not been laid before them.

27181. I do not know whether you would care yourself to go into the question of standards, or whether you would prefer that that should be discussed with your colleague, Dr. Wilson, but in connection with possible new sources of pollution do you think there would be any advantage in informing any person about to start a business what would be expected from him in the way of purification ?—Well, Sir, the way it presents itself to me is this: so far as the actual procedure is concerned it would very much facilitate matters if one could say to a manufacturer: "You will have to produce such and such a result," but what I feel is the difficulty is this, Sir. You have a stream which is very polluted. A comparatively low standard will be sufficient for the stream in its existing state, but as time goes on it is hoped the condition of the stream will improve, and consequently the standard of purity ought to be higher. I feel that a manufacturer would regard it as an injustice if he complied with a standard, and then in the course of years he were asked to provide some more effective purification. He would say: "I have done what was required by the Rivers

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Board—they told me what they wanted—there is no finality about this; they are always coming to ask for something a little better than I have done."

27182. Has your board recently considered—I know they considered it at an earlier date, but has it recently considered—whether it would not be good policy to lay down certain, not permanent but provisional, standards, and give a manufacturer an assurance that provided he carries out works to bring about that provisional standard he shall not be troubled for a good number of years; putting it clearly that something beyond that standard will ultimately be required?—They have not formally discussed that point of view during, at any rate, the last two years. It has been discussed informally by the chairman and myself, and so forth, but it has not been the subject of a formal discussion by the Rivers Board.

27183. Do you care to give us your personal view on that point? Would it not produce a great improvement in connection with the condition of the rivers if you could bring all the manufacturers up to a certain point, even if that point were not the ultimate point to be aimed at?—Well, Sir, I would prefer not to give you my personal view, because I do not think I have considered that question in sufficient detail for my opinion to be of any great value to you. I would rather, Sir, my colleague, Dr. Wilson, should deal with that.

27184. Very well. In your draft you make allusion to a difficulty in connection with the traders not being responsible for pollution, and throwing the responsibility on their employees; but surely the responsibility is on the proprietor and not upon his employees?—I was referring to cases where the contents of settling tanks, etc. were improperly discharged into the stream by workmen. You will see, Sir, that the words of the Act are: "Any person who causes to fall or flow or *knowingly* permits to fall or flow" various matters. Perhaps on the extremely technical interpretation of the Statute it might be held as a proposition of law that even when the workman was doing something which he had been absolutely forbidden to do the master was liable, although he did not actually know, and did not discharge this polluting matter. There is authority for that in the case of the Queen against Stevens in the year 1876, but I think it will be apparent to the members of the Commission that the Rivers Board stand a very poor chance of succeeding if they apply to a bench of magistrates to convict a millowner, when the millowner himself says: "I have given instructions to my man under all circumstances to put this refuse in a certain place. I have provided a spoil heap for it, and told him to use that and no other." The workman himself says: "It is quite true; I was acting contrary to instructions; I ought not to have done it. I did it to save myself a little trouble." I do not think, Sir, you would find that any bench of magistrates would be likely to convict the master under those circumstances.

27185. And, as a matter of fact, have you met with that difficulty? Has a bench of magistrates declined to convict in such a case?—No, Sir, because the Rivers Board have always felt that those were not cases which they could very well take to the magistrates. The difficulty has arisen, Sir; a case occurred in December where we had reason to suspect that improper use was being made of settling tanks at night. The inspector was sent up to watch. The very first night he was there at half-past ten he found a very bad discharge coming from these premises. He followed it up, and found that a workman had put a pipe into the settling tank and was running off all the accumulated sludge direct to the stream. The workman said: "It is true I have done this; I am sorry if it is an offence; I did not know it was an offence. I ought not to have done it; I had orders not to do it." The master said: "I have reprimanded the workman; I have done everything in my power to prevent this abuse of my works. I cannot help it if this man comes down at half-past ten o'clock at night and runs off this stuff." If one took proceedings one could not give in evidence a hearsay report—that we had had information that induced us to send our inspector up at night. There would only be the one isolated case to go upon.

27186. That case was not tried?—That case was not tried, Sir.

27187. Do you think it likely that the magistrates would have exonerated the manufacturer from the responsibility which rests upon him to see that his employees do their duty?—I think, Sir, the magistrates would have hesitated very much to adopt a construction of the Act, in face of the words "knowingly permit," which would make the employer liable in that case.

27188. It seems to me rather that you are guiding your policy without having really tested the point?—Possibly to that extent that may be so, Sir.

27189. What do you wish to say to us with regard to the difficulty with short tenancies? You say that where a tenant is only on the premises for a short remainder of a tenancy he alleges that it is not practicable for him to carry out works, and you rather suggest to us that the responsibility in such a case should be thrown upon the landlord to carry out the works?—What I would suggest, Sir, is that it should be made an offence for the owner of premises to let them for a purpose which involved the carrying on of a trade from which polluting liquids would be discharged unless he provided in connection with those premises suitable purification plant. That is to say, if he let them for a term of whatever you might think reasonable, say, less than five years, or less than a year. That is rather a point of detail as to what the exact time should be, but we have found cases where a dye house, for instance, has been let on so short a term as a week. Obviously you cannot take proceedings against a weekly tenant. Another case we have had just recently—a case at Morley. We threatened to take proceedings in 1906 when the man went into occupation. We took those proceedings, and in due course obtained an order. That order was made in June last, and suspended for six months to enable the man to construct works. During the six months he has not done a single thing; he simply remained as he was before. At the expiration of the order he left the premises. Dr. Wilson reminds me that those premises have changed hands five times in about ten years.

27190. (*Sir William Ramsay.*) Is there no possibility of following him, though he has left the premises?—No, Sir, because the order against him is that he shall abstain from discharging polluting liquids from this particular mill into a particular stream, and if another man takes that dye-house we shall have to start from the very beginning again.

27191. Then you suggest that the onus should fall upon the owner of the premises to provide sufficient purification plant?—So far as the provision of structural appliances is concerned in the case of a short tenancy, but if those structural appliances are not properly managed, then, of course, the tenant should be liable for any mismanagement.

27192. (*Chairman.*) When a new tenant takes a place on a short lease, I suppose you give him notice that pollution will not be permitted?—We do, Sir.

27193. You do that?—We do.

27194. And if he has not in existence any suitable plant, you give him notice that the plant will have to be provided?—That is so.

27195. But probably the arrangement for the short lease will have been made by the landlord before you give such notice?—Unfortunately, that is very frequently the case when we first ascertain that he has taken the place and is polluting. He says: "Well, it is very unfortunate but I have made my agreement, and I have no provision for calling on the landlord to do this work." We have a case of that kind just now at Birstal where the tenants are providing purification plant, although as a matter of fact they have only got a tenancy of something like three years, but they feel that it is a very hard case.

27196. If it were generally known in the Riding that the Rivers Board was able within reasonable limits of time to compel a tenant to carry out purification works, tenants would probably be more careful in making arrangements with their landlord?—I think that would be so, Sir.

27197. Then you suggest that your difficulties in this direction also are due to the delays which arise in connection with applying the law?—I think so, Sir; I think it has an effect.

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27198. And probably if by new legislation or otherwise those delays were greatly reduced, this difficulty would tend to disappear also ?—Well, it would exist, I think, but in a less aggravated form. I may say here, Sir that I am told by persons who know that members of a certain association in Yorkshire have got a form of agreement in use with their landlords, under which it is provided that if the Rivers Board obtain an order against a tenant the tenant is to be at liberty to leave the mill on giving one month's notice. That is a clause put in the lease with the express object of avoiding this liability.

27199. Well, that could be pressed to that issue ?—It could, Sir, with this result: that one would take proceedings; one would obtain an order against a tenant. He would leave the premises; another man would come in, assured of something like, at shortest, twelve months' liberty before we could get our order against him.

27200. Then clearly the whole thing turns upon the power of the Rivers Board to enforce their Acts within reasonable limits of time ?—I think so, Sir.

27201. Now, in the case of contractors who undertake for a manufacturer the purification of his waste liquors, you say that you also have some difficulty, but surely either the contractor undertakes to purify the liquid or he does not, and if your board is dissatisfied with the effluent produced, surely you can ascertain who is responsible, whether the contractor or the manufacturer, by asking for the production of the necessary documents ?—May I say on that, Sir, that if one asks the contractor, he says: " I am not going to show you what is merely a business agreement as to the terms I pay for grease. That is my private arrangement; it has nothing to do with you"; and the manufacturer takes the same attitude as a general rule.

27202. One is not surprised that the contractor should take that view, but what about the manufacturer ? You say to him: " You are responsible for this pollution, and you say you have made a legal contract with a third party to take this responsibility off your hands. Satisfy us that you have made such an arrangement." If he satisfies you that he has a legal contract with a third person to take this responsibility off his hands, then your course would be fairly clear, would it not ?—May I say, Sir, that if that were so, and we had a clear course against the contractor, it would avail us very little, because the contractor is at liberty to throw up his whole bargain at a month's notice, probably—on short notice, anyhow. If he has to purify the effluent he will not take it on; he will not continue on the same terms. We should get our order against him; we should have the order; it would be worth the paper on which it was written and nothing else.

27203. Then you would have a clear course against the manufacturer, who was not able to enforce his contract ?—Yes, but there again would be another delay of some twelve months in going against the manufacturer.

27204. And there again the question of the impracticability of carrying on your work in a reasonable time brings about the evil results that you speak of ?—To a very great extent, Sir.

27205. In the case of ochre water, I suppose that the difficulty has been tried by the Courts, has it ?—I do not think that it has actually been the subject of judicial decision, Sir, but we have been advised from the very beginning by very eminent advisers that that is not a matter which comes within our jurisdiction.

27206. That is a case of certain waters which are under the surface of the earth, and would remain there but for the fact that someone is carrying on the business of extracting coal or other minerals, and as an incident to that business raises these waters, and turns them, without altering their character no doubt, into the river. These waters are said to contain to some extent, not only these colouring matters, but also a certain amount of free sulphuric acid. Has that case ever been tried ? Seeing that it is in consequence of the carrying out of the business that this water is raised out of the ground and delivered into the stream, has no case been brought before the Courts to prevent the raising of such water, or to secure purification at all events to the extent of removing the acid ?—No, Sir, for this reason, that there is an express exemption in the Act for water raised from a pit, and discharged into a river in the same state as that in which it is raised. It is Sec. 5 of the Act of 1876. " Every person who causes to fall or flow or knowingly permits to fall or flow or to be carried into any stream any solid matter from any mine in such quantities as to prejudicially interfere with its due flow, or any poisonous, noxious, or polluting solid or liquid matter proceeding from any mine "—and these are the important words—" other than water in the same condition as that in which it has been drained or raised from such mine, shall be deemed to have committed an offence against this Act, unless, etc." And there is a similar proviso in Sec. 22 of the West Riding of Yorkshire Act, 1894.

27207. So it would appear that you are barred from any action by this clause ?—That is how we are advised.

27208. Do you know how that clause came to be introduced into the legislation of 1876 ?—I do not, Sir.

27209. (*Secretary.*) It is not based on the 1868 Commission Report ?—(*Dr. Wilson.*) I do not think so. Great attention was drawn there to the pollution from mines.

27210. (*Chairman.*) Then has your Board reason to believe that the acid water so delivered from mines into the streams is a cause of considerable injury ?—(*Mr. Atter.*) They have very good reason to believe that, Sir, both from the complaints they receive from the users of water, and from the reports of Dr. Wilson, their Inspector, and from the tests he has made.

27211. And does your Board believe that it would be practicable within a reasonable limit of cost to neutralise the acid in such waters ?—That, Sir, is a question which the Board have not decided, and you will see we have not made any suggestion here. It is simply put before you as a subject which really requires consideration.

27212. And new legislation ?—New legislation and prior consideration by a body like yourselves, to determine what is the proper method of dealing with the conflicting interests, the sanitary authority on one side, and the coal owners and other persons who are responsible for this pollution on the other. Dr. Wilson reminds me that the difficulty is particularly acute in the case of abandoned mines. The water still finds its way to the surface contaminated with this acid, but no one is carrying on any business there at the moment, and the works are abandoned. There is no one actually pumping it, there is no one actually working the pit and getting a profit from it.

27213. In such a case how does this water issue from the mine, if it be not pumped ?—By gravitation. It rises and finds its own level in the pit shaft, and overflows either at the pit shaft or at what are known as dayholes on the side of the hill at an outcrop.

27214. You merely name that point as one in which it is not possible for you to take any action, but as a point which is worth consideration in connection with any new legislation ?—That is so, Sir.

27215. In connection with your procedure you complain rather that the Local Government Board are not at present limited to matters purely legal, but that they decide whether liquid discharged is of a polluting character, and whether means for rendering it harmless are reasonably practicable and available ?—Pardon me, Sir; my point is that they ought not to be asked to determine anything more than that the liquids are polluting, and whether means for rendering them harmless are reasonably practicable and available.

27216. Is it not the case that they are so limited at present ?—They are not, Sir. Under Sec. 6 there are certain things that they are bound to take into consideration before giving or withholding their consent, but they take the view that it is not an exclusive limitation, and that they are within their rights in taking into consideration other matters. For instance I have looked through the proceedings, and I find it is several years since any manufacturer has raised the point that there are no means reasonably available for dealing with his refuse. There are cases, of course, where he has said, " I have not got in my possession sufficient room," or " there is no room available upon which to construct these works," but in no case during the last few years has he said that the tanks or filters, or whatever it is that Dr. Wilson advises, cannot purify this stuff at a reasonable cost.

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The defences chiefly raised have been these. They have said the Royal Commission has reported; there will soon be a Bill; you ought not to give your consent until that Bill is introduced. In other cases they have said: The Dewsbury and Batley Corporations are going to introduce Bills on the same lines as the Huddersfield Bill, giving us a right to connect with the sewers. Leave your consent over for some months, and let us see what they do. In other cases they have said, this into which we discharge is a sewer. If we discharge into a sewer we cease to be liable. Of course, that is a defence which has recently been over-ruled in a case we took to the House of Lords, and got judgment on November 26th last.

27217. But that is a legal point which you are quite prepared to leave to the Local Government Board ?—That, Sir, is a legal point which I should prefer to have decided by a court of law, rather than by the Local Government Board, for this reason; that I think it is obvious—it is agreed on all hands—that uniformity is most desirable. That can only be secured by a certain measure of publicity, which is gained by fighting a case in open court, and there you get a decision given by a Judge who gives his reasons for it, and subject to appeal to the highest tribunal in the land. The Local Government Board frequently, when they refuse their consent, absolutely refuse to give their reason. I have a case here where they were asked to give their reason, and they said: "We are not prepared to give a reason." That makes the position very difficult. We do not know what their reason is: we do not know what they thought was defective about the procedure or about the proof, or about the law. Proceedings have been greatly delayed on this very defence of the sewer. It was argued very strongly that a manufacturer who discharged his trade liquid into a sewer was absolutely protected, although through that sewer it went into a stream, but the House of Lords have now decided that that is not so; that a manufacturer is liable.

27218. What is the case you are referring to ?—The West Riding of Yorkshire Rivers Board *v.* Butterworth and Roberts. That case was decided at the County Court at Holmfirth. The manufacturers appealed to the Divisional Court; to the Court of Appeal; and to the House of Lords. The courts held that it was no defence to a manufacturer that he passed his trade liquids through a sewer if that sewer discharged into a river, and if the pollution at the outlet of the sewer could be attributed to his discharge. It is a very wide decision, Sir. If it is of any use to the members of the Royal Commission, I have a printed copy of the judgment in that case here which I shall be glad to hand in.

27219. It is of distinct interest, and it might be of use to know where these are available. Can you spare your copy ?—I can spare this copy, Sir. (*Copy handed to Chairman.*)

27220. There is a difficulty that you raise on another point, which rather surprises me. You say that a sanitary authority should have power in all cases to take proceedings in the firm's name against persons carrying on business in partnership. Surely they have that power?—They have that power, Sir, where proceedings are taken in a County Court under the Rivers Pollution Prevention Act, 1876, but I was rather referring to cases taken under Acts similar to our West Riding Act of 1894, where proceedings are taken before the justices. Then you have to mention in the information the names of the individual persons; say John Jones and Henry Smith, trading in partnership as so and so, and the conviction, if there be a conviction, is only as against those individual members. There are precedents for that, Sir, you will find, in the Alkali Works Regulation Act, 1881, Sec. 23, and the Factory and Workshop Act, 1901, Sec. 146.

27221. Then another difficulty you refer to, which seems rather a surprise, is that if you obtain an order against a firm, and there is some change in connection with that firm, the order is not effective on their successors ?—That, Sir, is a point which has been found in actual practice. I may mention one which is probably an extreme case. Proceedings were taken against a company, Messrs. Sands, Wilson & Co., Ltd. Application was made for consent to the Local Government Board to take those proceedings against them in October, 1900. A date was fixed for the application, and then search was made by us to get the certificate of incorporation, to be quite sure that we were right in the description of the company, because every technical defence that can be taken is taken, and we found that in September, the month before we had applied to take proceedings, this company had been wound up, and its business and premises had been transferred to a new company, called Sands, Wilson & Co. (1900), Ltd. The name plate on the door was exactly the same; the solicitor who was acting for the company very discreetly kept quiet. He gave us no information of the change. However, we happened to be just in time to withdraw that application and make a new application against Sands, Wilson & Co. (1900), Ltd., instead of Sands, Wilson & Co., Ltd. In another case we got an order against an individual millowner, Henry Sagar, who constructed certain works, but they were far from efficient. When we desired to apply for penalties, we found that he had turned his business into a company, and he was then trading as Henry Sagar, Ltd. We had to start again. As a matter of fact, we have an order now against Henry Sagar, Ltd. In the same way we have a case pending now, the Ramsden Mill Company—that was a partnership, not a limited company — in which their advisers wrote to me last year and said "the Ramsden Mill Company was not a registered company, and was owned by Mr. James Hill, and now we learn that he has sold both the premises and the business to Mr. Fisher, who, we understand, will continue to trade as the Ramsden Mill Co."

27222. In that case, had you an order ?—We had an order by consent, Sir, against the Ramsden Mill Company. I would rather not express a very decided opinion upon it, because it may be necessary to test that point in court.

27223. It has not been tested ?—That will be coming up presently.

27224. But have you in any case tested that; if any firm have submitted to an order, and agreed to carry out certain works and keep them in order, and they sell their business to somebody else ? Have you tested the point whether in selling their business they do not sell it subject to any undertaking that they have entered into ?—We have never taken a case into court and been defeated on that point, because in the earlier case I mentioned, Sands, Wilson & Co., we took the opinion of eminent counsel on the question, and we were advised that it was perfectly clear that we should not have the faintest chance of succeeding against these people. They were different persons in law although they carried on the same business; they are an absolutely different legal entity; and the order only binds the person or company against whom it is made. And I put it in this way, that we were not foolhardy enough to take proceedings in the face of the very best expert advice that we were able to get.

27225. Still, the case not having been tried, it seems a little premature to suggest alteration in the law until the existing law has been tested, to see whether it is right or wrong ?—Well, Sir, I think to a lawyer it is sufficiently clear, without actually testing it. You are aware, Sir, that the Rivers Board are very averse to taking proceedings when they are advised that the law is not on their side, simply to establish a principle, because they feel that every case they lose does far more harm than the good resulting from the decision of one point of law.

27226. Well, then you suggest, to pass on to another point, that the definition of "stream" should be amended on the new legislation, so as to define with greater accuracy what is the limit of tidal waters. What is it that you suggest there ?—Might I, Sir, before you pass on to that point, make one remark about orders binding successive owners, and that is that in the Middlesex Act, and in the Thames Conservancy Act, they have a power which is somewhat equivalent to the power I suggest. In the Middlesex County Council Act of 1898, Sec. 15, and in the Thames Conservancy Act of 1894, Sec. 95, there is a provision that notice given under those Acts shall continue in force, notwithstanding a suspension of the flow, and notwithstanding any change of ownership. The notice in those cases is very similar in operation to the Order which may be obtained under the River Pollution Prevention Act, because the procedure under the Middlesex and the Thames Conservancy Acts is this: in the case of existing pollutions they give notice to a person who is polluting, requiring him to desist within a certain time, not less than three months; that time may be extended. If he does not comply with the notice within the time limited, or the extended time, he at once becomes liable to a penalty of £100, and to a continuing daily penalty of £50 thereafter. Therefore, the effect of the notice if not complied with, is exactly the same as the effect of a County Court Order under Sec. 10 of the Act of 1876; and that notice is expressly made to bind successive owners, so that if notice has been given to Jones to do this work within three months, and he leaves at the end of one month, and Smith takes the premises, Smith will be liable at the end of the time, although the notice was given to his predecessor. Those sections I rather crave in aid as precedents.

27227. Have you said all you have to say on that point?—There is one other thing I should like to mention, Sir, while we are dealing with the Middlesex and Thames Conservancy Acts. Under the Middlesex County Council Act, the Thames Conservancy Act, and the Lee Conservancy Act, there is no necessity to obtain the sanction of the Local Government Board, or any other sanction, before taking proceedings even against manufacturers. I have carefully read the Acts, Sir, and verified that by direct inquiry from the advisors of each of these boards.

27228. That is not a manufacturing district, is it?—Well, Sir, I should have thought that the Lee, from the little knowledge of it that I have, was polluted by a good number of manufacturers on its course.

27229. But there is nothing like the development that you have on the Yorkshire rivers?—Oh, not to the same extent, Sir.

27230. Then passing on to the other point, you suggest that the definition of a stream should be amended. What is just the alteration that you suggest?—On the tidal question, Sir?

27231. Yes?—What I should prefer to see personally would be some absolute limit on each river if that were practicable It might possibly be practicable to take the tidal limit as marked on the Ordnance maps. That, however, is possibly rather more than one could hope. In the alternative, what I might suggest is this, that in any case where the defence was raised that the stream into which the discharge took place was a tidal river, the Central Authority, when constituted, should inquire into the circumstances of the case, and consider whether, in the particular circumstances, the fact that the river was technically tidal should exonerate the defendant from liability. The experience we have had was in a case against the Tadcaster Council. Tadcaster is 76 miles from the North Sea, up a river which certainly does not appear to anyone to be tidal. Elaborate tests were made and it was found that there was no upward flow, no ebb and flow in the ordinary sense of the word, but the High Court were satisfied that there was such a rising and falling of the water, caused by or attributable to the tide, as to make it tidal. They said in effect that where there was a rise and fall which you could trace to the tide the water became tidal, although in this case this was fresh water for many miles, and the only effect was that the tide coming in dammed the water back, and the water not being able to get away, it naturally rose. I am afraid it was rather the joke of the district that Tadcaster was on a tidal river. There were two inches, I think, of rise and fall at medium tides; therefore, we lost the case.

27232. On those grounds?—On those grounds. It was an appeal to the High Court on that very ground.

27233. (*Sir William Ramsay.*) Any river could be proved tidal under those circumstances?—Well, Sir, Dr. Wilson reminds me of certain cases in the neighbourhood of Thorne where it is low lying ground and the streams flow down into the Humber, which is admittedly tidal. At the outlet of each of these streams there is a sluice which acts automatically by the action of the tide. When the tide comes in the sluice is closed; the water cannot get away and is dammed back. There is very little distinction in effect between that case and the Tadcaster case, the main difference is that a sluice is introduced to make an absolute dam instead of the mere wedge action of the tide coming in.

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27234. (*Chairman.*) In that case did you apply to the Local Government Board to find that that portion of the river was a stream?—We did not, because that can only be done on sanitary grounds, and, as a matter of fact, these particular offenders, the Tadcaster Council, have since that time managed their works in such a way that there is very little nuisance. It is not with regard to the Tadcaster people alone that I was dealing with the point, but it is as illustrating what might happen. Of course there is the remedy you pointed out, Sir, that if the discharge continues to such an extent as to make it desirable on sanitary grounds, the Local Government Board can deal with it.

27235. That rather minimises the importance of the point, does it not?—Well, Sir, sanitary grounds are very different grounds, I think, from the mere question of the pollution of the rivers. I speak subject to correction, of course, but it always seems to me there is a grave distinction. You would have to prove the effect upon health I take it. I think the same difficulty has been experienced in Lancashire. Dr. Wilson says that he does not think the Local Government Board have ever given their consent to declare a river tidal.

27236. They have been asked to do so?—I cannot remember at the moment whether they gave their consent or not. I think the same point occurred in Lancashire in a case where the council consented to an Order, and it was held they were estopped afterwards from disputing it.

27237. (*Mr. Tatton.*) With regard to taking samples you suggest that the law should be altered to some extent—Yes, Sir.

27238. Would you give the inspectors power to go on to the premises, or is this suggestion to apply only outside the actual boundary of the work?—I think, Sir, in the majority of the cases it is necessary that the inspector should have power to go on the premises; I think he should have that power, limited in such a way of course as not to interfere with the trade process being carried on at the time. That should be expressly limited, I think. You will find, Sir, a precedent for that in the Middlesex County Council's Act of 1898, Sec. 11, and the Thames Conservancy Act of 1894, Sec. 98, and still wider the Middlesex County Council General Powers Act, 1906, Sec. 7. It gives power to enter the premises between nine in the morning and four in the afternoon, and to open up drains, reinstating them when the examination has been made. Then again, Sir, under the Alkali Works Regulation Act, 1881, Secs. 16and 17, there are very wide powers to enter and inspect any premises, to examine the processes and to make tests, and the sections provide that the owner of the factory shall give facilities for the examination, but that is limited, as I suggested, Sir, in these words, " but so as not to interrupt the process of the manufacture. "

27239. Would not that power be very strongly opposed by the manufacturer?—I do not think so, because in effect in nine cases out of ten they are only too glad to show Dr. Wilson and myself what is going on. There are, however, several cases where the manufacturer is very obdurate. He stands on his rights, and he says "you can take a sample if you can get it at the point where it goes into the stream. If you come within this door of mine, I shall know how to deal with you." There is one example in Halifax known as Old Lane. There are three mills one below the other. The top mill discharges into an underground conduit about 5 or 6 feet in diameter. That conduit runs underground and receives the drainage from the second mill. Still underground it receives the drainage from the third mill. Now the man at the top shows us what he puts in; he shows us where he puts it in. The second man says you shall not come on my premises at all, and so far we have never been able to get on his premises. The man at the bottom puts no difficulty in our way, but it is impossible to get up that conduit; it is full of water, it is full of steam; a man would be taking his life in his hands. Then again there was another case—I have the plan of it here, Sir—where the discharge from a mill is under the floor of the mill directly into a goit. You will see, Sir, this blue thing is the river. (*Exhibiting plan.*) The goit runs across on this dotted line; there is a weir here; the water is taken above the weir; it goes down here, then under the mill in conduit, under the river in conduit, under

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this field, then down here and under a second mill, and then into the river. The discharge from the first mill takes place at that point through the mill floor. Obviously a man cannot get up to take a sample at the point where it gets into the stream, and when it gets out into the river you cannot say it is a discharge from this mill, or a discharge from that mill.

27240. Would you rather have that power, or would you rather have some power of getting an Order of the court in any particular case where you have a difficulty of this kind ?—From the point of view of practical working it would be desirable to have an Order of the court, provided that Order did not limit the inspection to a certain time, because if the Order were simply that you might inspect, say, at ten o'clock in the morning, I think one would find a very good effluent being discharged at that time.

27241. Could he do that, except he stopped the processes going on in the mill ?—You mean could he make a good effluent ?

27242. Yes.—Very often. Dr. Wilson says there are means ; he knows the working better than I do.

27243. (*Sir William Ramsay.*) Would it not be a mistake to limit it between the hours of ten and four ?—I think it would in Yorkshire. I was merely quoting the Middlesex Act. In Yorkshire the system of mill working is such that a great deal of overtime is worked.

27244. (*Mr. Tatton.*) But do you not think with regard to special inspectors, that the fact that they have no power of entry now is one reason why they are well received ? If they had the right, they could say: "We can come in and you cannot stop us." Would not that set the manufacturers against them ?—It depends rather on the individuality of the particular inspector.

27245. It does ?—I can quite imagine that a tactless inspector armed with the power might make himself very objectionable, and probably frustrate the very object that he had in view, but so he might as things stand at present.

27246. (*Sir William Ramsay.*) I think under the Alkali Act the inspectors have power compulsorily to enter ?—They have. I have the clause here.

27247. And there is no ill-feeling so far as I know ?—I do not know of any ill-feeling ; I have never heard of any.

27248. I have not heard of it ?—No, Sir.

27249. (*Mr. Tatton.*) Now, with regard to the responsibility when the liquid is dealt with by a contractor who is not the occupier of the premises. Would he not be invariably responsible to you, the Rivers Board ? I mean, could he possibly shift the responsibility on to his sub-contractor ?—May I give you an illustration, dealing not with the woollen industry for the moment, but with the coal industry ? As you are probably aware, there are in Yorkshire a number of collieries where patent coke ovens have been put up. These coke ovens have been put up mainly with the idea of extracting the by-products and getting value from them. They are put up by an independent company. The company contract to construct the coke ovens, to work them, and to return to the colliery company the coke which has been made from the coal. They themselves get their whole profit from the by-products which they extract in the process of making the coal into coke. Now, those are huge works, costing many thousands of pounds. The coal company have no control over them, their liability begins and ends when they hand the coal to the by-product company and receive the coke back from them, and this patent coke oven is always on the premises which belong to the colliery company. There, Sir, we have always treated the contractor as being certainly liable, though possibly the colliery company may in some cases be jointly liable. In some cases it is true the coal owners have accepted responsibility, but there again the point has not been actually fought out. This is a comparatively modern creation, and is merely an illustration that occurs to one, as showing a case in which it would be difficult to say that the owner of the original stuff, the colliery owner, was liable. Dr. Wilson reminds me of another case, the case of Hemingway. The Local Government Board refused us consent to take proceedings against a millowner, because it was stated at the local inquiry on the millowners' behalf that a contractor, or as they call it in Yorkshire, a seakman, had contracted to take the grease and deal with it so as to make it into oil, and the Local Government Board were of opinion that that absolved the owner from liability, although no formal agreement was put in, and I rather think, from memory, there was no formal agreement ; it was a mere verbal agreement.

27250. Did the Local Government Board give that as their reason for refusing consent ?—I will read you their letter, Sir. "The Board observes that it was given in evidence which was not rebutted that the seak tanks which received the polluting scouring effluent from the mills were held not by the millowner, but by a person who took the effluent for his own use under a contract, and that the pollution was caused by the tank owner and not by the manufacturer. It appears, moreover, that at the present time another arrangement has been come to between the mill-owner and the person referred to, under which the millowner intends to treat all the liquid waste from the mill. In these circumstances, the Board do not feel that they are in a position to give the consent applied for." Then my predecessor, Mr. Edwards, dealt with that in a letter in which he pointed out that no evidence had been given as to the terms of the contract between them. The whole thing was merely suggested in a vague and indefinite way, but the Local Government Board said that they did not find any sufficient ground for altering their decision.

27251. (*Sir William Ramsay.*) May I ask the date ?—The date of that, Sir, is January 30th, 1904.

27252. (*Mr. Tatton.*) Then would you suggest in a case like that that the occupier should be responsible always ?—I would, Sir, because otherwise he may put up a mere man of straw, and surely it is within the spirit of the Act, if it is not within the letter, that where a man hands over liquids to be dealt with in such a way that he knows they must of necessity reach the stream in a polluted condition, he ought to be liable, and he should not be able to avoid his liability simply by selling his stuff for a secondary purpose to another man.

27253 (*Sir William Ramsay.*) That, of course, would require to be limited by stating "on his premises," if the second man took the stuff away elsewhere ?—Exactly, Sir. You will notice in my summary I say *on his premises*, because we have cases in Yorkshire where these grease contractors have works of their own, to which they convey the effluent from two or three different mills.

27254. (*Mr. Stafford.*) Just one question about the jurisdiction and the Local Government Board procedure under Sec. 6 of the Rivers Pollution Prevention Act, 1876. I see that you prefer the jurisdiction of the Courts ; but do you not think the method as it is is much simpler and a much cheaper method ?—May I say this, that as far as the inquiry goes, to ascertain whether means are available or not, and whether the liquid is polluting, I much prefer the Local Government Board as a tribunal ; but when it comes to deciding a legal point, purely a question of law, then I prefer the decision of the Court.

27255. Would not that increase litigation ?—I do not think so, Sir. I think it would minimise it, because one case on each of the points I have mentioned, would decide the question once and for all, and it is argued out at Local Government Board inquiries time after time. Then, too, Sir, these inquiries are held, as you know, by very competent officials of the Local Government Board, but officials on their engineering staff, and one can readily imagine what a difficult thing it is for a lawyer to argue a pure proposition of law before a layman.

27256. Are there any shorthand notes taken at these inquiries ?—In our own cases, Sir, we nearly always have a shorthand note.

27257. Does not the shorthand note go before the Local Government Board ?—It does not unless they ask for it. It is taken for ourselves.

27258. But the inspector's note, such as it is, on any legal question, comes before the Local Government Board ?—Such as it is. My point is that the non-legal mind cannot really take a proper note of the legal argument.

27259. I think you misapprehend the position ; the inspector who holds the inquiry is not the person who gives the decision ?—No, Sir, I do not.

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27260. The evidence goes before the Local Government Board. The Local Government Board have competent legal advisers on their staff. Is not that so?—That is agreed.

27261. If the evidence is duly put on paper, or if the inspector takes a full note of it and takes a full note of all the legal objections, it is not quite right to say that you are not getting to some extent a legal decision?—May I put it in this way, Sir, that a person who has not received some legal training is not competent to take a note and to appreciate the salient points in a technical legal argument.

27262. Has the inspector not got a shorthand note taken on these occasions?—No, Sir.

27263. Are the evidence and arguments not taken down?—No, Sir. As a matter of fact we do at our own expense have a shorthand note taken of most of the cases for our own purposes.

27264. But is not the evidence of each witness read out by the inspector, and do not the legal gentlemen on either side correct his note, and say they wish such and such evidence recorded?—That is not done, Sir.

27265. But if a witness gives evidence, surely at the end of his evidence the evidence he has given is read out to him, and he has to sign it?—No, Sir, that is not done.

27266. It is not?—I do not know the contents of the inspector's note in any case which I have conducted. I know as a matter of fact by following his pen that he must have taken very brief notes indeed of many legal arguments which have been addressed to him at considerable length.

27267. (*Chairman.*) You are referring to enquiries on oath. In those cases the inspector does take it down verbally, and it is signed at the end.

27268. (*Mr. Stafford.*) I was referring to inquiries held by Local Government Board Inspectors in Ireland, in which shorthand note-takers are employed to take a full note of the whole procedure in these cases, and the legal argument appears *in extenso* before the Board, and I thought it might possibly be the same here. (*To Witness.*) You have given us very strong reasons against legal procedure in connection with Sec. 10 and Orders under Sec. 10. You have shown us there are very great difficulties and delays and troubles. Would it not be very much simpler if the Order were made by the Local Government Board, instead of by proceedings before Courts of Session?—I agree, Sir, it would be very much better if the Local Government Board had power to make the Order in the first instance without going through all this procedure prior to getting to the Court, but I should only prefer that method if the Local Government Board would give their reasons why they either consented or refused to make an Order. One is not able to gather the working of, may I call it, the mind of the Local Government Board if they merely say, we consent or refuse an Order. It is no guide in many cases.

27269. You will see there may be good reasons why they should not give reasons as to why they arrive at a given decision?—I can see there are reasons from a Departmental point of view.

27270. Do you not think it shortens the procedure, makes it easier, and makes it cheaper, to have decisions of that sort, rather than costly decisions by a Court of law?—No, I do not, because if the case is once decided that is an end of it. For instance, take this point of the liability of a manufacturer who goes through a sewer. That has been decided once for all; even the Local Government Board are bound by it.

27271. Supposing the Local Government Board were to give their reasons in all cases, supposing your suggestion were adopted, that only in cases involving a question of law there should be an appeal, do you not think that the question of law would be brought into every case? Would it not be almost impossible to exclude the question of law?—I think not, Sir, with the able advice which is at the service of the Local Government Board.

27272. I think with the able advice of the legal profession on both sides of the case they would find it very easy to get a question of law involved?—May I put it in this way? From my point of view as an official I deprecate litigation very much indeed. Although a lawyer by profession, I am merely an official in practice, so I do not think you must paint me with the brush that you apply so generally to our profession.

27273. (*Sir William Ramsay.*) Would you regard it as right that the Central Authority, which has been recommended in the Report of the Royal Commission, should pronounce upon all matters of fact connected with such questions as you have been bringing before us?—Certainly, Sir.

27274. That the law Courts should only be brought in after such matters of fact have been determined in that way?—Yes, I would very much prefer, Sir, that such a tribunal as you suggest should deal with all questions of fact. I do not consider the law Courts are the best or even a good tribunal for deciding questions of fact, because they are tied by strong rules of evidence, but I suggest they are the best and most satisfactory tribunal to decide the proper interpretation to be put upon the words of a Statute.

27275. The whole question of law should not be raised without the consent of your Central Authority?—Yes. I am sure, if there were a central authority established, they would be only too anxious to co-operate with us in getting obscure points decided.

27276. (*Chairman.*) We will not detain you longer; you have given us very useful information, and put it before us in a very clear way. I gather that while you suggest certain alterations in the law, the main difficulty which is acutely before your Board at the present moment is the continuance of the period of uncertainty pending legislation, and the main point that you urge upon us is that legislation ought not to be longer delayed?—May I put it, Sir, that there are two grounds. There is the temporary cause of delay operating just now, and there is the permanent difficulty of procedure, with the incidental delay of getting before the Courts and getting a decision. They both come to the question of delay.

Dr. H. Maclean Wilson, Chief Inspector of the West Riding Rivers Board; Examined.

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27277. (*Chairman.*) You are the Chief Officer of the West Riding Rivers Board?—Yes, Sir.

27278. What is your exact title?—Chief Inspector of the West Riding Rivers Board.

27279. And we have had the advantage of receiving from you evidence on several previous occasions?—Yes.

27280. And to-day we are to hear from you some information in regard to pollution of the Yorkshire rivers which is due to trade effluents? I may take it that the Yorkshire rivers for the most part are most seriously polluted?—With regard to the pollution by trade refuse, Sir, that concerns mainly the rivers Aire and Calder.

27281. And their tributaries?—And their tributaries. The other rivers, some of them, are in a natural state. The River Don is grossly polluted by ochre water which was mentioned to you this morning, but to a very slight extent by trade refuse.

27282. But the whole of Yorkshire is an important manufacturing district, and the number of sources of pollution is very great?—Very great.

27283–4. In your report upon trade refuse, which you have been good enough to send to us, I see that you mention eighty-three gas works, in which the gas liquor is sold to some chemical manufacturer to be dealt with by him?—Yes, Sir.

27285. And you also mention four special works where the glycerine is recovered, and where no pollution has been discharged into the river for several years, although there is possibly at times a pollution from these works; and you say that, excluding these works which are referred to, there are in your district 2,005 premises in which trade refuse is produced?—Yes.

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27286. And of these how many are drained into public sewers at the present time ?—1,064.

27287. And that is a larger number than in your previous report of 1905 ?—Yes, there are constantly fresh premises being connected up to the public sewers.

27288. Then subject always to the local authorities satisfactorily dealing with the mixture of sewage and trade effluents, the connection of these 1,064 sources of pollution to the sewers removes the difficulty from those sources ?—That is so, it lessens the pollution of the streams by so much.

27289-90. Then for the present we may limit our enquiries of you to those cases which are not so connected, and where the effluents drain into the streams ? I take it that there are 941 premises discharging into streams ?—Yes.

27291. And the purification works of some kind have been provided in 651 cases ?—That is so, Sir. These are by no means all satisfactory purification works.

27292. No, but of some kind ?—Of some kind. There has been an attempt to purify the refuse.

27293. I am anxious just at first to get the general figures to guide us ?—You will understand that these numbers are constantly changing, but I have not troubled you with the alterations which have taken place since the date of this report in May of last year. There have been a great many alterations since then, but I thought it better not to confuse you by mentioning them in this report.

27294. They are changing. I understand the figures are approximate ?—They are altering every day, but are approximately correct.

27295. Then I understand that there are 290 premises where the trade refuse is discharged into the stream without any attempt at purification ?—That is so, but that figure includes a great number of cases in such places as Halifax, Huddersfield, Heckmondwike and Dewsbury, where the sanitary authorities have either under special Acts or under the general Acts resolved to deal with the trade refuse, and connect all the manufacturing premises up to the public sewers, but great difficulties have arisen in connection with these special Acts, and the preliminaries have not yet been settled, except in the case of Halifax. I hope that all these manufacturing pollutions in these towns will be done away with very shortly by the connection up of these premises to the public sewers, say within the next twelve months.

27296. Then speaking generally the policy of your Board has been to encourage local authorities to receive trade effluents into their sewers, subject always to suitable conditions, and subject also to the volume of the trade effluent not being excessive ?—I should not like to put it that way, Sir ; I think rather that the Rivers Board has stood absolutely neutral between the manufacturer on the one hand and the sanitary authority on the other. They have recognised that if a sanitary authority receives the trade refuse of its district into its sewers, it is taking a considerable burden on its own shoulders, and they have left it to the sanitary authority and the manufacturer to agree with one another, whether or not the trade refuse should be received into the sewers. Naturally the Board prefers that the trade refuse should be received into sewers, because this very much lessens the pollution of the streams, and lessens enormously the number of points of pollution.

27297. But surely your Board views with approval the reception into the sewers of trade effluents ?—Yes, I think so. I can go so far as to say that.

27298. Your Board considers, does it not, that it is more economical and more practicable for a local authority to deal with a multitude of minor effluents at all events, than to call upon each individual producer of such effluents to purify and to prevent pollution ?—I think they do, Sir, but I do not think the Board has ever formally come to any conclusion of the kind. That is their feeling I am sure.

27299. Then, as a fact, connection to the sewers is progressing ?—Yes.

27300. And local authorities are increasingly willing to receive trade effluents, and to deal with them *en bloc* ?—That is so. Before you pass from that, Sir, it may be interesting to you to know that the tendency is, and it is an increasing tendency, for sanitary authorities to take trade refuse into their sewers, without any previous treatment at all, on terms of payment. For instance, in Halifax, the whole of the trade refuse is now received into the sewers, and the Corporation call upon the manufacturers to pay them a certain sum for dealing with the crude refuse, although under their special Act they have the power of insisting upon preliminary treatment ; and that is the tendency generally.

27301. That is a detail with which your Board need not concern itself ?—No, Sir, it is really no business of ours, but I thought it might be interesting to you, as showing the tendency of the sanitary authorities.

27302. (*Sir William Ramsay.*) That is, their payment is in addition to what they contribute to the rates ?—Yes.

27303. (*Chairman.*) Now we return to the 941 cases in the West Riding, where trade effluents are discharged direct into the streams, and it would be interesting to us to have on our notes from what sources these trade effluents come.—

Trade.	Premises discharging to streams		Premises discharging to sewers.	Totals.
	Untreated.	Treated.		
The Coal Trade	—	59	—	59
The Leather Trade	11	40	92	143
Brewing, Malting, and Grain Washing	68	30	149	247
The Paper Trade	—	18	8	26
Silk, Cotton, Woollen, and Worsted Trades	163	314	483	960
Bleaching	1	13	2	16
Wire Drawing, Plating and Galvanising	3	34	61	98
Chemical, Gas, and Soap Trades	11	41	108	160
Stone Working	1	41	8	50
Miscellaneous	32	61	153	246
Totals	290	651	1,064	2,005

There are 87 gas and soap works where polluting liquids are produced, but are not discharged to streams.

27304. Well, now, of these various sources of pollution, which are the more important, in regard to volume or in regard to excess of pollution ?—In regard to the effect upon the streams, there is no doubt that in the West Riding the woollen trades are by far the most important. You will see, Sir, that I have included in one group silk, cotton, woollen, and worsted trades. I have been unable to divide these, because in so many mills woollen and cotton industries are carried on at the same time. Goods are made partly of woollen and partly of cotton, and it is the same in connection with the silk. And you will also see that I have been unable to make a division between dye-works and ordinary woollen mills, because in Yorkshire at least the majority of the manufacturers do their own dyeing, and it is quite common to have, say, both wool washing and piece scouring and dyeing carried on in the same premises. I have therefore made no division in my report between these different processes.

27305. (*Sir William Ramsay.*) You put bleaching separately ; do they not then do their own bleaching ?—No, Sir, bleaching is most generally done at a place where there is no great pollution from wool washing or dyeing. In some cases there is bleaching as well as dyeing.

27306. They rarely bleach wool, but they bleach cotton, do they not ?—Yes, there are very few places where they bleach wool.

27307. (*Chairman.*) But so far as the West Riding is concerned, the main difficulty arises in connection with the treatment of wool ?—That is the biggest pollution by far.

27308. And that arises in connection with the washing of wool ?—That is one of the greatest pollutions, in polluting character, but not in quantity. The quantity of polluting refuse which comes from actual wool washing is very small indeed, compared with the quantity which comes from piece scouring, the scouring of the goods after they are woven, or their dyeing, but it is of a vastly more polluting character.

27309. And that is really one of the most difficult effluents to treat ?—It is.

27310. It is, I believe, in almost every case treated so as to withdraw from it the grease, as far as it pays to do that ?—Yes.

27311. And that is done, is it not, mostly by what are known as seak tanks ?—That is what they are called in the West Riding ; I believe in Lancashire they are called sap pits.

27312. But in Yorkshire they are known as seak tanks ?—Seak tanks.

27313. And the object of these tanks is to remove part of the grease from the wool-washing waters ?—Yes.

27314. These seak tanks have been in operation for many years in certain mills ?—They were reported on, Sir, by the previous Commission, in 1867 or 1868. They were in use then.

27315. And the main object with which they use them is not the purification of the effluents, but to obtain as much grease as it will pay to withdraw from these waters ?—That is so. The effluent is still very polluting after the removal of this grease.

27316. Now in the West Riding certain mills have been in advance of others, and have endeavoured, have they not, to purify the waste waters from the seak tanks ?—I am afraid, Sir, I have not got any good instance to give you of the effective purification of the effluent from seak tanks in connection with wool washing. It is a very difficult effluent to purify ; it is very full of dissolved organic matter, and, as a matter of fact, I do not think I can refer you to anything better in that connection than is mentioned in this report of November last on the treatment of wool-washing refuse, where the effluent from the seak tanks for wool washing is simply filtered through cinder filters ; and the final effluent, as you will see from the analysis, is still a grossly polluting liquid.

27317. Is there not any settlement in some cases before filtration ?—Settlement is part of the process of the grease recovery. There is described in this report a preliminary settlement of the suds from the wool washing to get rid of sand. Then the suds are treated with sulphuric acid to separate the grease in the form of fatty acids. These are deposited in the seak tanks in the form of a sludge, and the acid liquid which is separated in the seak tanks is run on to filters and filtered.

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27318. Direct ?—Yes.

27319. Does not this supernatant liquor also contain certain matters in suspension which can be settled when treated by precipitants ?—No, Sir, the grease which is separated entangles all other matters in suspension, and they go down with what is called magma, the greasy sludge, and all matters in suspension can be thoroughly removed from a seak tank effluent by filtration through cinders.

27320. (*Sir William Ramsay.*) I suppose the stuff consists very largely of organic salts of potash, does it not ?—They are there in great proportion.

27321. (*Chairman.*) I suppose the cases are few, if there are any at all, where the wool washing water is discharged into the stream without first extracting such portions of the grease as would pay to be extracted ?—I cannot remember any, Sir, now. There were up till quite recently several cases.

27322. We may limit our attention, therefore, to the water which flows from the seak tanks ?—Yes, Sir, pretty fairly.

27323. And you say in certain cases that effluent passes over filters ?—Yes.

27324. Well, now, what sort of purification is obtained by that process ?—Simple straining, with the filters that are provided. They are always, I may say, too small to act as anything but simple strainers.

27325. Then it is not that the process is ineffective but that it is insufficient ? If the filters were of sufficient area, would you expect to find considerable improvement in the effluent ?—I see nothing, Sir, to prevent the biological purification of these effluents on filters ; in fact, the Commission is no doubt aware that the acid effluent from the Bradford sewage works has been purified on biological filters. That is practically the same kind of effluent as comes from the seak tanks in the case of wool washing.

27326. Only largely mixed with domestic sewage ?—It has been largely mixed with domestic sewage.

27327. That modifies the problem, does it not ?—It is much less polluting than the ordinary seak tank effluent from the washing.

27328. But in the case of the effluents from the seak tanks, what sort of results have you been able to note from filtration ?—Simple straining, Sir.

27329. Then what is the result ? Is the final effluent still greatly polluting ? What is its character ?—Very polluting indeed, much worse than ordinary sewage.

27330. What is its character ?—It is a straw coloured clear liquid, acid in reaction, and containing large quantities of organic matters in solution ; but from a good seak plant with proper filters containing next to no matter in suspension.

27331. (*Sir William Ramsay.*) Are those organic matters fermentable ?—Not so long as the liquid remains acid, and I cannot say that I have made any experiments as to the neutralising of them, but it is quite evident, I think, from the character of them that they would be fermentable when neutralised.

27332. When mixed with sewage they certainly appear to ferment ?—They do.

27333. Would it not be necessary to mix them with sewage in order to get fermentation to start ?—I do not think so, Sir, judging from the experience of Bradford, if the acidity is kept down. The acidity would probably require to be at least nearly neutralised.

27334. (*Chairman.*) You have told us that as a rule the filtration is ineffective, because of the small area of the filters. Have you any case at all where seak tank effluent has been treated so as to produce a final effluent which may be considered satisfactory ?—Not from wool washing ; not one.

27335. Although you are unable to mention any case where that has been successfully accomplished, do your own experiments, and does your own opinion, lead you to the belief that it is possible to bring about that result ?—I have no doubt it would be possible, but it would be exceedingly expensive, because of the very strong character of this seak tank effluent, and the very great amount of organic matter present in it. If you take the effluent from the acid precipitation of the Bradford sewage, it

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is found much more difficult to purify than any ordinary tank effluent from sewage works. This liquid that you are now speaking of from the seak tanks would be very much worse than the acid effluent at the Bradford sewage works.

27336. Well, then, the position is this. Here is an effluent flowing from a great many sources which is very polluting, which at present has not been effectively purified. Can you suggest to us any process by which it would be possible to avoid the pollution from that source ?—I feel quite certain, Sir, that this liquid could be effectively purified by bacteriological processes, by percolating filters, but it would take more filtration than any ordinary sewage would take.

27337. And you suggest that it could only be done at such impracticable cost as to make it in effect impossible ?—Well, I should not like to say that, Sir, because I have not made any estimate of the cost, and I have no experiments to guide me in that.

27338. In fact, no one in the West Riding has yet carried out a purification plant by percolating filtration which has enabled you to see satisfactory results ?—That is so, Sir.

27339. Nor has your Board itself made any experiments in this direction ?—No, Sir. There have been experiments made. For instance, one or two of the manufacturers discharged this acid seak tank effluent from wool washing through filters of limestone, with a view of first neutralising the effluent, and then getting some biological purification, but these experiments were not satisfactory. In fact, they only led—and this, perhaps, answers another question of Sir William Ramsay—to the putrefaction of the effluent, and it was found very much better to allow the grossly polluting acid effluent to be discharged into the stream by degrees, than to have it passed through a limestone filter, and be discharged in a putrefactive condition.

27340. Then would the fact of neutralising the acid by other means produce the same objectionable result ?—Unless the liquid were further purified.

27341. Well then, there is the fact that a considerable amount of the pollutions of the West Riding are due to seak tank effluent, and at present you are unable to refer us to any case where it has been satisfactorily treated ?—That is seak tank effluent from wool washing. I want you to make a clear distinction in your mind between that from wool washing and that in the case of piece scouring.

27342. Piece scouring is much less objectionable ?—Much less.

27343. And much weaker ?—Yes, what is present is much more easily removed.

27344. (*Sir William Ramsay.*) Is it not ordinary soap ?—It is ordinary soap, and nearly all soap and grease.

27345. (*Chairman.*) It is what arises from the washing of wool which has been previously washed ?—That is so in effect; yes. We have now some very excellent works in the Riding for dealing with the suds from piece scouring. I have sent in to-day two extra reports. One of them, unfortunately, is not completed; the analyses are not added; I will have to send them afterwards.

27346. What are the Hopton Mills, Mirfield ?—They have piece and yarn scouring and dyeing.

27347. They have seak tanks ?—Yes.

27348. They withdraw the grease ?—They withdraw the grease.

27349. Then they pass the effluent from the seak tank into certain settling tanks ?—Yes, along with what are known as washing-off waters; that is the final washings from the scouring of the pieces.

27350. And from these settling tanks the effluent passes on to filter beds. Are they percolating filters ?—They are used continuously; there is no special form of distribution. There is a fine layer at the top of the filter which aids in the distribution of the liquid.

27351. In this case your Report tells us that the results have been excellent ?—Yes, that is from the piece and yarn scouring.

27352. Then with a proportionally increased area of filters, would it not be likely that you would get similar results in connection with wool scouring ?—The area of the filters would have to be enormously increased, the liquids are so totally different. May I put it this way, Sir, that all the solids that are present, all the polluting solids that are present in this effluent from piece scouring, are easily removed by chemical precipitation and filtration, but it is not so with the solids present in the wool-washing suds. You can remove the grease by chemical precipitation and filtration, but you still have remaining large amounts of dissolved organic impurities.

27353. Then effluents from piece scouring do not offer the same difficulties ?—They do not.

27354. They may be satisfactorily treated ?—Certainly.

27355. But at present those from the original wool washing are a difficulty ?—A very great difficulty.

27356. And no means has yet been found of treating them satisfactorily ?—No.

27357. Has your Board undertaken, or is it likely to undertake, any laboratory or other experiments, with a view to solving this particular difficulty ?—I think, perhaps, the Board might have done more in that direction had it not been for the fact that the Commission was understood to be taking the matter up, because it does not really come within the scope of the work of the Board. As you are aware, Sir, the Board has undertaken experiments, some little experiments, in the treatment of trade refuse, but it is quite beyond the legal scope of our work.

27358. But is it not possible for your staff, in connection with your experience in the laboratory and in connection with these various works, to suggest lines of experiments ?—Oh, quite, Sir, and we do that. I am daily talking over the principles upon which purification works should be constructed with manufacturers, and with engineers employed by them, but I think my Board would find it difficult to expend money upon the construction of works. They have in one case. A report that I sent in upon the treatment of brewery refuse was based upon experiments which we ourselves carried out, a small sum of money having been granted to me for making experimental filters, but I think it is very doubtful whether we have any power to do that legally.

27359. I gather rather from what you said that someone—your Board or manufacturers—expected that this Commission was going to make experiments in this direction ?—That is so. I myself would have urged upon my Board strongly that it was their duty, if they could do it legally, to carry out experiments in dealing with these various liquids as a guide to the manufacturers. But I have talked it over with the Chairman, and agreed with him that, as the Commission were expected to take up this matter and make experiments, as they have done in the case of the distillery refuse, it was much better to leave the matter with you.

27360. And you suggest that this is one of those difficult problems which this Commission might advantageously take up ?—Decidedly.

27361. Are there in your district any associations of manufacturers who would be likely to assist the Commission in this matter of experiments ?—Are you dealing with wool-washing alone, Sir ?

27362. Yes; yarn-washing and piece-scouring effluent, you tell us, can be practically dealt with ?—Yes.

27363. But the other one is a difficult one to deal with, and as yet you are unable to refer us to any case where is has been satisfactorily dealt with. Therefore, it is suggested somebody should study the matter ?—Yes.

27364. Now, have you any association of manufacturers who would be likely to respond to a call by this Commission to expend money under our guidance for the purpose of finding a solution ?—I can only suggest the big wool combers' syndicate, Wool Combers, Ltd., Bradford, and I may say in connection with them that the Rivers Board is calling their attention to two very gross pollutions which arise from works of theirs, and with which they will have to deal, so that I should think they will quite be in the mind to welcome any experiments that you might like to carry out on their works; and I may also add that their chemist, Mr. Walter Leach

—no doubt you know him personally—is a most excellent man to watch these experiments for you, or to assist you in them.

27365. You suggest to us that it might be useful to us to approach that company ?—I do.

27366. But is there not apart from that company, some association of manufacturers in your district ?—There is the Mill-Owners' Association with which the Commission has made acquaintance, but they have done nothing, absolutely nothing, so far as I know, towards evolving methods of purification.

27367. They have limited themselves to defending cases, and getting off their members on technical points ?—That is so. They have done no work towards purification of refuse, so far as I know.

27368. There is such an organisation, and it might possibly be worth the while for this Commission to communicate with them ?—Yes, they could no doubt arrange for the Commission for certain mills where experimental works could be carried out.

27369. Would that Association be a body to give evidence on the legal aspects of the question which Mr. Atter referred to ?—I should think they would like to be heard. Mr. Mills is their solicitor.

27370. I should think it is exceedingly likely that they would not only like, but expect to be heard ?—I think so, Sir.

27371. (*Sir William Ramsay.*) Would you expect that the Associated Dyers, the body you mentioned before, would also like to be heard ?—I think they would. I mentioned Wool Combers, Ltd. I do not know whether they would like to be heard on the legal question, but I am sure they would be interested, and would welcome any assistance that they might derive from the experiments of the Commission. At these two mills of which I spoke there is ample room and opportunity for these experimental works to be set up.

27372. (*Chairman.*) We might pass on now, Dr. Wilson, so far as I am concerned at least, to another source of pollution—that arising from coal washing in the West Riding ?—Yes; that, Sir, I suggest you should deal with along with the spent gas liquor, because now, at least within the last ten years, the two things occur very much together.

27373. Washing of coal arises in connection with the burning of coal in close vessels for producing coke ?—That is so mostly.

27374. Then the evil arising from the discharge of coal-washing waters has been largely reduced, has it not ?—Very greatly.

27375. In some cases the water is used over and over again, and there is very little effluent, and in other cases the effluent has been so far purified that it can properly be admitted into the stream ?—That is so, Sir. If you will look at the Table you will find that every one of the fifty-nine coal-washing premises has its refuse treated, and there are only quite a few, not more than half-a-dozen, places where we have often to complain of the pollution by coal-washing refuse, because now the colliery proprietors recognise that they can deal with this coal-washing refuse readily.

27376. (*Sir William Ramsay.*) How is it done; would you mind explaining ?—Simple settlement, Sir.

27377. Not filtration ?—In a few, a very few, cases they do filter finally, but they are very few.

27378. (*Chairman.*) In some cases they pump the effluent after settlement on to spoil banks, do they not ?—In one or two cases they do.

27379. And it filters down through those ?—Yes.

27380. They have also filters of the ordinary kind in some places ?—In one or two cases. I can remember two cases.

27381. And what sort of effluent results ?—Of course, it is an effluent which contains a good deal of inorganic matter in solution. It is hard, but it is quite clear and bright, and produces no visible effect upon the stream.

27382. It is not putrefactive ?—Oh, not in the least; there is no dissolved organic matter in it at all.

27383. Then the evil arising from that source has been greatly reduced ?—Enormously, and I should like to add there, Sir, that it has been greatly reduced to the great profit of the colliery proprietors.

27384. Has this change which has taken place been largely due to the action of your Board ?—I think entirely, Sir, and, if I may say so, to the education of the colliery owners to the fact that it is to their profit to stop the pollution.

27385. This was at one time a serious source of pollution ?—Oh, enormous. There are places in the Riding—I am afraid I have not the exact figures, but you may take it that something like 100 to 200 tons of coal a week were discharged into the streams from individual collieries, coal which they now recover.

27386. (*Mr. Tatton.*) Do they not use the water over and over again; has not that reduced the volume ?—That has had a great deal to do with stopping the pollution. In all new washers they arrange to pump the water over and over again. They do not need clean water, what we should call clean water, for washing the coal. I think I have described it in one of these reports, Sir; it is a process of dividing the real coal from the shale and stone, because of the different specific gravities, so that even dirty black water full of fine coal is good enough for the purpose. I should like the Commission to take a note of this, that even in any colliery where they say they use the water over and over again it is my experience that there always comes a time when there is a discharge, and it is absolutely necessary in my opinion that there should be a sort of stand-by reservoir or tank into which that excess discharge can be received. They can go on for a week or a month pumping the water round and round, but a day comes when they must empty the washer, and they must have some place to put the water that is there.

27387. (*Chairman.*) A stand-by tank is required ?—Yes.

27388. We may take it from you that the evil arising from coal washing has been largely reduced, and you see no difficulty at all in the collieries avoiding any pollution from that source ?—That is so, Sir.

27389. Then we pass on to what is a much more serious matter, the question of the gas liquor which is produced in connection with collieries.—That is a very serious matter, and I do hope the Commission will take it up amongst their first inquiries.

27390. Gas liquor is produced in connection with coke ovens and in connection with the manufacture of illuminating gas ?—Yes, and in other parts of the country, in Lanarkshire more especially, in connection with blast furnaces. These are the three sources.

27391. The three sources, but the two apply mainly to the West Riding ?—To the West Riding, yes.

27392. So far as the manufacture of gas is concerned that does not trouble you very much, because the effluents, such as they are, are discharged as a rule into the sewers ?—That is so, Sir. In the majority of the gas works in the West Riding the gas liquor is stored and sold to chemical manufacturers. Mr. Brotherton, who appeared before you, is one of the chief of these, and he deals with the gas liquor from a large number of small gas works. That is so generally with regard to illuminating gas.

27393. It is simply the effluent from these subsidiary works that passes into the sewer ?—Yes.

27394. And in most cases, therefore, no great trouble arises in connection with the streams from gas liquor from gas works ?—That is so. There is the trouble—I daresay you do not wish to go into it to-day—that arises on the sewage works which receive this gas liquor. That is a subject which is receiving some attention in the West Riding at present.

27395. If the volume of gas liquor is large relatively to the sewage, certain difficulties have arisen ?—That is so.

27396. (*Sir William Ramsay.*) It acts as an antiseptic, I suppose ?—Yes, and in certain cases—an increasing number of cases—the gas liquor is being subjected to a preliminary treatment before being received into the sewers.

27397. (*Chairman.*) It might be convenient if you will just mention to us those local authorities in your district

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that have found trouble in the treatment of the mixture owing to the relatively large volume of gas liquor, and which are the places?—Rothwell Urban District receives the gas liquor from a set of patent coke ovens, and that liquor has altogether upset their sewage works. Swinton Urban District receives gas liquor from a chemical manufacturer, and they are there at present constructing works for the preliminary purification of the gas liquor. Brighouse Corporation are manufacturers of gas and discharge their own gas liquor into their own sewers, and they have constructed works for the preliminary purification of their gas liquor. These are perhaps the most important.

27398. Then in those cases where trouble is likely to arise, can that trouble be avoided by preliminary treatment of the gas liquor?—Yes, Sir. I would direct the Commission to what has been done by Mr. J. Radcliffe, of East Barnet. He has in several cases put down works for the preliminary treatment of gas liquor, with the result that, he assures me—and I have seen reports from the surveyors of the authorities he refers to—that the gas liquor so treated has not caused any difficulty at the sewage works, but, as a matter of fact, seems to aid in encouraging bacteriological life, in increasing the numbers of organisms that are found in the mixed sewage and gas liquor afterwards. He has reports by Mr. Otto Helmer to that effect.

27399. What is being done by those local authorities, of which you gave us the names just now, with a view to doing away with the difficulties?—At Rothwell the gas liquor from the coke ovens gets a fairly effective settlement before it is turned into the sewers, but that is all the treatment, and the sewage works, which are comparatively new, have been so disorganised that the sanitary authority now are applying to the Local Government Board for sanction to a loan which will enable them to carry out an extensive scheme of percolating filters. At Swinton the authority has called upon the manufacturer to put in this method of Mr. Radcliffe. At Brighouse they have also adopted Mr. Radcliffe's method. May I also refer you to Bradford? I had forgotten this case, which is a very interesting one. The Bradford Gas Works all belong to the Corporation, and the gas liquor is all conveyed to chemical works which adjoin the sewage works. The sewage works engineer has advised them, I believe, that it will be impossible to admit all the spent gas liquor into the sewers, because it would quite upset any biological purification of the sewage. They are at this present moment experimenting; they have constructed filters—percolating filters—under the advice of Dr. Fowler of Manchester, and on these percolating filters they are purifying the gas liquor. That is a most interesting thing, Sir, for the Commission, because it is the unmixed gas liquor that they are distributing upon these percolating filters.

27400. Unmixed with sewage?—Unmixed with anything. At first Dr. Fowler mixed it with ten times its volume of water from the Beck. Now he takes the filter effluent, and dilutes the crude gas liquor coming in to ten times its volume by means of the filter effluent.

27401. (*Sir William Ramsay.*) From the sewage works?—No, from the treatment of the gas liquor.

27402. I see?—He puts the crude gas liquor on the filter; he takes nine parts of the effluent that comes off and mixes it with one part of the crude effluent, and puts that on the filter again.

27403. (*Mr. Tatton.*) Was the Beck water polluted, or was that a fairly clean stream?—It was fairly clean water he was using in the first instance.

27404. (*Chairman.*) But I suppose your experience, and also Dr. Fowler's, was that dilution of some sort is necessary?—Certainly.

27405. Before it went on the filters?—I may say I did not believe Dr. Fowler to start with, that even with this ten times dilution he could get any effective purification through a percolating filter of this liquid.

27406. And he has?—He has. I believe his claim is that he has reduced the oxygen required by 75 per cent. by this method.

27407. Effluents coming from the gas liquor are effluents that absorb oxygen to a very large degree?—Oh, tremendously. Two or three hundred parts per 100,000.

27408. (*Sir William Ramsay.*) Is that due to bacterial action or to some chemical?—It is due to the bacterial action. The number of bacteria in the filter effluent is enormously greater than in the liquid that goes on to the filter, and the action does not take place until the filter has been ripened by the addition of some organic matter, such as sewage. He has had such a filter going for I think two years in Manchester, at Bradford Road Gas Works, Manchester, and there I believe he constructed a filter with the material which he took from the Davy Hulme filter beds already ripened. In the Bradford experimental filter he took the material, and ripened it by adding, I think, weak urine for several weeks, until nitrates appeared in the effluent, and then with the filter so ripened, and evidently containing bacterial life, he begun to treat a weak solution of the chemical refuse, gradually increasing it in strength. It is a most interesting experiment.

27409. (*Chairman.*) But would not that point to the advantage of diluting the gas liquor with sewage?—It would, Sir.

27410. Where it is practicable to do so?—Yes, it would; and it points to the fact that this gas liquor can be dealt with along with sewage in a proper state of dilution. If the proportion of gas liquor is not too large, it can perfectly well be dealt with mixed with the sewage.

27411. Evidently the question of the admixture of gas liquor with sewage is a point of very great importance for us to investigate?—It is.

27412. To-day, perhaps, we had better limit ourselves to the discharge of gas liquor effluents direct to the streams. In connection with this gas liquor I suppose in every case it is just treated for the purpose of withdrawing from the liquor certain valuable constituents, such as ammonia and tar?—Yes.

27413. It is only an effluent after those processes have been passed through?—That is so.

27414. After all has been withdrawn which it pays to withdraw, there remains still in the effluent ammonia in some form?—Very little.

27415. Not much?—The ammonia has been distilled out.

27416. There is some?—There is; quite a trifle.

27417. Then what is the characteristic of the final gas liquor such as is turned into streams?—It is an exceedingly complex liquid, Sir. It contains sulphides in innumerable forms, phenols and sulpho-cyanides, and these are the polluting ingredients to a great extent.

27418. Sulphide compounds?—Sulphide compounds.

27419. And that effluent is of a very objectionable character?—Exceedingly.

27420. Not from the point of view of putrefaction, but from the point of view of injuring fish, and making the water unsuitable for the drinking of cattle, and of course for human consumption?—It is, Sir. It is very poisonous. We have had a number of cases in the West Riding where fish have been killed and cattle poisoned by the discharge of this liquid into the streams.

27421. The manufacturer or the contractor who deals with the liquors may be trusted to withdraw from them all that it would pay to withdraw from them?—Not always.

27422. But after all that has been done, the result is still extremely unsatisfactory?—Very.

27423. Is the volume large?—May I refer you, Sir, to a very interesting paper which has just been given?

27424. Is that in reference to the volume?—Yes. It has been given to the members of the Midland Institute of Mining Engineers, by a Mr. Theodore Kochs, and it is in reference to a special arrangement of the works for the recovery of the ammonia from the gases, and he goes very minutely—in considerable detail at least, into the quantities of liquids that are produced. There are tons of refuse per oven per day. From a plant of fifty ovens, 100 tons of effluent would require to be disposed of.

27425. How many gallons per ton of coal do you think there would be produced?—I think I have the exact figures here, Sir.

27426. Tell me how many cases there are where they have coke ovens; how many collieries are there?—Ten years ago there was only one; now there are twenty-three.

27427. And that is a source of pollution that is constantly growing ?—Constantly growing and likely to increase, and each of them has about 15,000 to 30,000 gallons a day of spent gas liquor to dispose of.

27428. Each of these twenty-three ?—Yes.

27429. That gives us about the volume I was asking for ?—Yes.

27430. Now, what efforts have been made to purify that effluent ?—Very considerable. The companies have invariably put down in the first instance settling tanks to take the spent lime out of the gas liquor ; that they have done at once without pressure at all. Then that has never been sufficient, and some of them have pumped it on to burning spoil banks. If the spoil bank is big enough there is no effluent ; the liquor disappears.

27431. It is largely evaporated ?—It partly percolates away, and is largely evaporated. Some of them have turned it into old coal workings where it disappears, or old quarries, but there is still a large number who are discharging this tank effluent into the streams and causing great pollution. It is rather a curious fact that almost all these collieries where they have these patent coke ovens are on small streams, where the volume of effluent in some cases is nearly equal to the volume of the stream in dry weather, and that causes intolerable pollution.

27432. Is the volume sufficiently small to permit of the consideration of a plan of evaporation, complete evaporation ?—We have one place in the West Riding where that method is adopted ; that is a method of artificial evaporation, if I may say so, where evaporating furnaces are constructed.

27433. And what has been the success of that ?—It has only been going now for about six months. There has been no complaint at all of it, and no discharge as far as we know of any gas liquor. The place is the Hemsworth Fitzwilliam Colliery at Hemsworth. That method has also been adopted at places in Scotland. I saw one at Dalmellington, in Ayrshire.

27434. The plant is a Scotch plant made in Glasgow ?—It is a Porion evaporator. I do not think it is made in Glasgow. The liquor is sprayed into ovens—furnaces which are heated by waste gases from the coke ovens. That is the whole system.

27435. Then evidently, if it were possible to carry out a plan of that kind, you would have no effluents, and, therefore, no pollution ?—No pollution of the streams.

27436. Yes, no pollution of the streams. One is interested, therefore, to know how far this is practical. Will it—I will not say pay to do it—but will the cost not be prohibitive ?—It is very costly. I may say that they have had to adopt it in the Hemsworth Fitzwilliam case, because the land-owner obtained an injunction to prevent them discharging the refuse into the stream, because of the damage they did, poisoning cattle and fish.

27437. Do you suggest that you are afraid it is not practicable to do away with the effluent altogether by evaporation ?—It is evidently practicable, because they are doing it in this case, but it is costly.

27438. I mean really practicable ?—They continue to make a profit out of their process even with this added cost, but it is a costly method.

27439. Can you suggest any other way of dealing with this objectionable effluent. Have you any complaint of the evaporating process tainting the air ?—I have never had any serious complaints I have no doubt that the evaporation into the air does create a smell, and as you are aware, Sir, in the West Riding especially a colliery when set up damages the vegetation all round. I fear myself that the evaporation of these liquors into the air is likely to increase that damage to the vegetation, and it cannot be very wholesome to the people who live near, either, but I have no great complaints of that.

27440. It would not be a fresh nuisance ; it would simply be an increased nuisance ?—It would be a nuisance in another direction ; you would get it in the air instead of in the streams.

27441. But inasmuch as the air is already so far contaminated that the vegetation is destroyed ?—That is so.

27442. The harm produced by this additional pollution in the air might not be very great ?—That is so, and it would be difficult to attribute its own amount of harm to this additional pollution.

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27443. At any rate, nothing has reached you in the way of complaint from the use of such plant ?—That is so.

27444. You were about to say there might be other ways of dealing with this ?—A great many men have been turning their attention to this kind of pollution. You have a report from myself upon the various methods that were in vogue at that time for dealing with it, and you have also a report from Dr. Grossman, of Manchester, who has proposed a method for purifying the refuse. Dr. Fowler, whom I mentioned before, has his method. Mr. Radcliffe has his method, and Mr. Kochs, in this paper to which I referred, has a method by which he proposes to lessen the amount of gas liquor by some 60 or 70 per cent. ; not a process of purification of the liquor, but a means of lessening its amount. Now, I may point out that, so far as is known at present, I believe I may say there is no known method of purifying this liquid sufficiently to enable it to be discharged into a stream. I know that Dr. Fowler claims that he can make it sufficiently pure to be discharged into a stream if he is allowed to dilute it with 10 volumes of pure water, but the Rivers Board has never recognised dilution as a method of treatment. But it can be so purified that it can be re-used. At these collieries where they have coke ovens, they have always coal washing ; they have the quenching of the coke when it comes out of the ovens ; and they require water in the scrubbers to wash the gas. These are all processes which use up large volumes of water, and they can I am perfectly certain—I think you will be able to convince yourselves from these reports—purify this refuse sufficiently to enable them to re-use it in any one or other of these processes, and as a matter of fact some of the manufacturers are doing so now.

27445. (*Sir William Ramsay*). Permanent disposal of it ?—Yes.

27446. (*Chairman*). That does away with the necessity for completely purifying it ?—Yes.

27447. If they can so far purify it as to consume the water for other purposes ?—That is done at some places.

27448. But those places would produce an effluent the character of which to some extent would be influenced by this gas liquor ?—That is so, but if you take a typical colliery where they have coal washing, coke making, coke quenching, and recovery of ammonia by washing the gas, you have there a set of processes which are bound to consume water, and by sufficiently purifying the gas liquor the whole of it can be used up in the other processes, together with additional fresh water, and that is actually done at some of the collieries.

27449. Then you are satisfied that the serious evil which hitherto has arisen from the discharge of gas liquors into streams can be avoided ?—I am ; yes.

27450. Will you be good enough to refer us to the particular places that we should visit in order to see where this has been effectively done ? Yes, Sir ; there is Hemsworth Fitzwilliam Colliery, where the process of evaporation is adoped.

27451. Where is that ?—At Hemsworth.

27452. Near Wakefield ?—Just half-way between Doncaster and Wakefield.

27453. Can you give us a case where the liquor is so far purified as to permit of its use for other purposes within the same works ?—Shall I give you instances of every kind.

27454. Of every kind where it would be worth our investigation.—There are so many instances. At Wharncliffe Woodmoor Colliery it is used up.

27455. We do not want too many. We should like a few typical cases. You have given us one where there is complete evaporation. You have given us another where the effluent is so far purified as to permit of its use within the colliery ?—Yes, and the third one is where it has been disposed of by putting it on a burning spoil bank.

27456. Yes, where is that ?—The Barrow Colliery, near Barnsley.

27457. If these are the only works in which you think the work can be properly done, it is no use giving us others

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where you know quite well the work is unsatisfactory?—No, Sir.

27458. There is no case where filtration has been satisfactory?—None at all, Sir; there is no case. And I may say it is the same on the Continent, because my Board have sent me over to Germany to inquire there what was done with this refuse.

27459. Where is the place where we should see the work of Dr. Fowler?—Bradford Sewage Works at Frizinghall.

27460. At Frizinghall?—At Frizinghall.

27461. I think we might now adjourn for lunch?—Would you allow me before you finish, Sir, to suggest that you should see Mr. Radcliffe's process for the partial purification of this refuse at St. Albans Gas Works. He has a small plant working there.

27462. That is a case where gas liquor is being treated before mixture with sewage?—That is so; it is so far treated that Mr. Radcliffe claims—and I believe rightly—that a similar effluent could be used for these other processes which occur in connection with coke ovens.

The Witnesses Withdrew.

Mr. THOMAS MUNRO, Solicitor and County Clerk of Lanarkshire; and Dr. JOHN T. WILSON, Medical Officer of the County of Lanark, called in.

Mr. THOMAS MUNRO examined.

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27463. (*Sir William Ramsay*) (*in the Chair.*) I think we may take it, as in the case of the other witnesses, that this evidence of which you present a precis, may be printed as part of our proceedings, and if I ask you a few questions to elucidate any points which you may wish to dwell on more particularly, that may best serve the purposes of the Commission?—Yes.

(*The Witness handed in the following Statement.*)

I am a solicitor and county clerk of Lanarkshire. I have been in the service of the county council since 1892.

The steps taken by the county council in the matter of the prevention of the pollution of the River Clyde and its tributaries and other streams in the county will be narrated by Dr. Wilson, the county medical officer, but I am prepared to speak to anything that has taken place since 1895 when the question was first seriously taken up by the county council.

I may be allowed to state as a general proposition that the result of the action of the county council, so far as it has gone, has been to demonstrate:—

(1) That, contrary to the generally accepted idea in Scotland, the Rivers Pollution Acts are capable of enforcement, both as regards sewage and trade pollutions; but that

(2) They call for amendment in two respects, viz.:—

(*a*) So as to avoid the prolonged litigation that certain of their provisions give rise to, and

(*b*) To permit of certain pollutions (discoloured effluents and water from mines) being dealt with.

I further submit that attention requires to be directed to the existing statutory enactments of the Public Health (Scotland) Acts and the Rivers Pollution Acts, because it is possible to construe these Acts as if there were a conflict in their provisions so far as relating to the obligations of the local authority to provide for the reception into their sewers of trade effluents. As relative to this point, I would mention the question of the effect of the introduction of unpurified trade effluents on sewage purification works, as to which the statutory enactments are silent and the decisions thereon vague.

I will deal with these points *seriatim*, but before doing so I may mention that I have read the evidence of Mr. A. Murray, of the Local Government Board for Scotland, given before the Commission in 1898, and that I agree with his summary of the Acts relating to the question of rivers pollution in Scotland, subject only to the qualification that I consider there is a difference between the law in burghs and counties in regard to the question of the responsibility of the respective local authorities to provide in their sewers for the reception of trade effluents. I refer to this matter hereafter.

Since Mr. Murray gave evidence only one material change has been made on the statutory enactments which he dealt with. At that time the law was that the whole cost of drainage or sewerage works carried out in burghs, under the Burgh Police Acts, fell to be met by a rate levied wholly upon owners. By the Burgh Sewerage, &c., Act, 1901, the incidence of taxation for this purpose is altered, so that, where that Act is adopted, the sewer rates now fall equally upon the owner and the occupier, which is also the statutory rule in counties.

Mr. Murray referred to the fact that in Scotland money borrowed for drainage works must be repaid within thirty years. I mention this because it has been felt in many cases that this is too short a repayment period, and efforts have been made to have it extended by general legislation, but hitherto without success.

My council, however, recently obtained, by Provisional Order, power to extend the repayment period to fifty years, but in respect only of works required for sewage purification, there being included in that term the cost of the actual purification works, the land, and the sewers that are required to convey the sewage from the drainage system to the works, and the purified effluent from the works to the natural outflow.

I believe that if a similar discretion were conferred on all local authorities there would be a greater willingness to deal with the problem of rivers pollution, which is presently retarded by the high rates which the construction of purification works involve.

I deal now with the specific matters first alluded to.

1. *Results of Litigation in Lanarkshire under the Acts.*—Since 1895, the county council have dealt with a very large number of pollutions arising both from sewage and trade discharges. In the great majority of cases remedial measures were taken without the necessity of appealing to the courts. There have, however, been *seven* cases taken to court—three against burghs and four against private firms in respect of trade pollutions.

The cases against two of the burghs are still proceeding, but at every step, so far, the county council has been successful. In all the other cases final decisions, absolutely in favour of the county council, have been obtained, except on one point which I may, in passing, refer to, as it is not unimportant. It arose in this way:—

A colliery company had been causing pollution. After repeated warnings an action was raised in court. Immediately before or during the proceedings the company executed remedial works. The court found that there had been pollution, but, in respect of the execution of works (which had only been executed a few days before, and after all the expense of preparing for the proof had been incurred) deemed it unnecessary to issue an order on the defenders as the county council had craved.

I consider that an order should in such cases be granted. Otherwise the result is that, in the event of further pollution, the council must begin *de novo*, which seems unreasonable.

In another case now proceeding, where the judgment is in favour of the county council on their main contention, the sheriff has expressed the opinion that the expression "solid and liquid sewage matter" has a restricted meaning, and only applies to human and animal discharge. This seems a wrong view, and, if it were generally accepted, it might make it still more difficult to successfully prevent pollution arising from drainage works which accommodate trade effluents as well as ordinary sewage

I have said that the county council have succeeded in administering the acts, but they have done so under great difficulties, which leads me to remark on the—

2. *Amendment of the law which our experience suggests.* (*A*) *As regards legal proceedings*.—I have prepared a statement which I can put in if necessary to show the various steps of procedure that have taken place in the several actions in the courts in which the county council has been engaged. Summarised it shows that between courts of the Sheriff-Substitutes, the Sheriff-Principal, and the Court of Session the proceedings have extended over the following periods:—First case, Burgh of Motherwell, four years; second case, Westburn Colliery, three and a half years; third case, Turner's Ltd (Collieries),

four and a half years; fourth case, Dunlop & Co., Iron Works, one year nine months; fifth case, Carnbroe Chemical Co., four years three months; sixth case, Burgh of Airdrie, three years five months and still pending; seventh case, Burgh of Coatbridge, three years five months, and still pending.

Three main reasons have, in my opinion, contributed to this prolonged litigation:—

(1) The ease with which each step can be appealed (competently or incompetently) from the Sheriff-Substitute to the Sheriff-Principal.

(2) The permission to take any point in the process before the Court of Session by special case under Sections 11 and 21 of the Act of 1876; and

(3) The necessity for an elaborate and fresh proof in every case that arises.

I suggest as a remedy, that whether or not, as might be contended, the action should be taken direct to the Sheriff-Principal to the exclusion of the Sheriff-Substitute:—

(1) No appeal from one court to another should be allowed except on a final judgment, save only in a case where a special point emerges on which leave to appeal is granted by the inferior court.

(2) The procedure by special case to the Court of Session should be abolished, as it has, I believe, been practically done in England, and that, accordingly, appeal to that court should only be competent on a final judgment of the inferior court, or on a special point granted by leave.

My experience has been that the appeal by special case has been taken advantage of to an extent never contemplated, and it is for many reasons unsatisfactory. For instance, it is difficult, and in some cases impossible, to state the whole facts of an elaborate proof, and the Court of Session have indicated that they will not look at the actual notes of evidence, but will confine themselves to the facts stated in the case. The result has been that judgments on parts only of the case have been given, necessitating recourse to the court again by a further stated case on other aspects of the question not previously disclosed.

3. The experience in Lanarkshire goes, in my opinion, to show the necessity for the avoidance of elaborate and fresh proof in every case. This is now necessary notwithstanding that the same points may have been enquired into or determined in an exactly similar set of circumstances. In other words, the desirability of having a central authority as recommended by the Commission, seems to be confirmed by the experience in my county. Such a central authority would, under remit from the courts, determine all questions of fact, leaving it to the courts to decide legal questions, and to enforce an Order based on the Report of the central authority.

B. Amendments as regards Pollutions not dealt with by the Acts, or as to which there is doubt.—

(1) *Innocuous Discolouration.*

This is a question for experts, but it seems to me that from the legal point of view the saving in Sec. 20 of the Act of 1876 makes it exceedingly difficult to deal with a pollution, a characteristic of which is discolouration. The fact of discolouration being present seems to imply the inference that the effluent is harmless, and to throw an undue burden of proof on the prosecutor. From the practical point of view also my experience has been that a highly discoloured liquid introduced into a stream, however harmless its chemical properties may be, is looked upon by the public as a very real and serious offence. I have one instance in my mind where continued and persistent protests have reached the county council against the continuance of such a pollution, and I can well understand and sympathise with the public, who do not appreciate the reasons that weighed with the legislature in granting this exemption.

(2) *Water in the same condition in which it has been Drained or Raised from a Mine.*

The question of whether the exemption conferred by Sec. 5 of the Act of 1876 should be continued is again one of policy, but it seems to me well worthy of consideration whether it should not be repealed or modified. If it applied only to a natural outflow of the water one could appreciate it, but when artificial means are required to release the water or to divert its flow, and when in that process it is possible that contamination takes place, the case seems altered, and calls for reconsideration.

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I desire now to briefly direct attention to the respective enactments of the Public Health (Scotland) Acts and the Rivers Pollution Acts in their bearing on the question of the reception into the public sewers of trade effluents.

I.—*The obligation, if any, on the Local Authority to provide Sewers for the reception of Trade Effluents.*

Under Sec. 103 of the Public Health (Scotland) Act, 1897, it is provided that the local authority shall have "power to construct such sewers as they may think necessary for keeping their district properly cleansed and drained." This is clearly an enabling and not an obligatory provision. There is no compulsitor on the local authority except where it can be shown that through their default the sanitation of the district is not being attended to. It cannot, I think, be held to compel the local authority to construct sewers sufficient to carry off all trade effluents in their district. Further, there is no statutory enactment on this point, even in regard to Special Drainage Districts, formed under Sec. 122 of the Act, which is silent in the matter.*

Contrasted with this, Sec. 219 of the Burgh Police (Scotland) Act, 1892, which applies only to burghs, seems to make it clear that it is compulsory to provide sewers capable of dealing with the whole sewage of the burgh, whether trade or otherwise. As Sec. 103 of the Public Health Act, 1897, also applies in burghs, town councils seem to be under two materially different codes.

[As will be again referred to, owners or occupiers of works in burghs who are prohibited from joining the burgh sewers obtain a relief of taxation to the extent of three-fourths of the sewage rate.]

There is no authoritative decision on the point, but it seems to me reasonably clear if Sec. 103 is read alone that, in counties, there is no express obligation on the local authority to provide sewers for every trade that may exist at the time of their construction, or to lay down sewers to accommodate new manufactures.

Sec. 110, however, provides that any owner or occupier of "premises" within the district who pays the Public Health General, or the Special Sewer Rate respectively, shall be entitled to cause his drains to empty into the sewers of the local authority on his complying with the regulations of the local authority as to the mode in which the connections are to be made, and provided further that the sewage is not of a nature to cause damage to the *structure* of the sewer, or by admixture with other sewage therein to cause a nuisance.

By Sec. 120 the local authority may compel the owner of a distillery, manufactory, or work without a sufficient drain, to connect with any sewer brought within 100 yards of such distillery, etc.

By Sec. 112 the owners or occupiers of distilleries, manufactories, or other works are compelled, wherever possible, to provide means for the reception of the refuse of such works so far as offensive, or injurious, or dangerous to health, or to use the best practicable means for rendering the same inoffensive or innoxious before discharging it into any river, stream, ditch, sewer, or other channel.

It is difficult, on a construction of these several sections, to say exactly what is the position of the local authority, and whether they import any obligation on the local authority to provide sewers sufficient for every manufactory within their district.

It seems reasonably clear that there is no obligation—at least none that can be enforced—on the local authority to lay down sewers that will accommodate every manufactory within the district, or that they must construct new sewers to suit the requirements of works that may be established subsequent to the laying down of the main scheme.

On the other hand, a difficulty obviously arises where a manufactory which produces an unobjectionable effluent desires to have the same accommodated in an existing sewer, and is prepared to convey the effluent to such sewer and to make the proper connection. If the capacity of the sewer is sufficient to carry the effluent, there can be no difficulty—the connection must be afforded. But if the sewer is too small, can the local authority be compelled to enlarge it or to construct a new sewer? Either course might result in an expenditure that would be prohibitive. All the provisions of the Act of 1897, with the

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* Looking to the peremptory terms of Section 15 of the English Public Health Act, 1875, I doubt whether the decisions that have turned on that section would be followed in counties in Scotland.

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single exception of Sec. 110, infer that there is no obligation on the local authority in such circumstances. Sec. 110 does, however, especially as it proceeds on a reference to the obligation to contribute to the rates, infer that there is a reciprocal right to obtain facilities.

Sec. 110 of the Act of 1897 has, however, to be contrasted with the provisions of Sec. 7 of the Act of 1876, which expressly allow a local authority to refuse admission of trade effluents to their sewers where these are only sufficient for the requirements of their district.

The Courts seem to read the Act of 1876 into the Public Health Acts, but the point as to whether the Public Health Act might not reasonably be said to stand by itself as regulating the rights of ratepayers in relation to the means which the local authority should provide for their accommodation is not free from doubt.

In any case, the two Acts seem capable of being interpreted as expressing two different and conflicting views of the Legislature, and the point should accordingly be made clear.

This could be done by expressly enacting either :—

(1) That the local authority should have the power to refuse to accommodate trade effluents which their sewers, as constructed for the ordinary requirements of their district, are incapable of accommodating ; or

(2) That they should only be bound to receive such effluents on payment of an adequate return for the extra expense caused over and above what the ordinary requirements of the district call for.

In this connection the provision of the Burgh Police Act, relating to abatement of taxation where facilities cannot be afforded to individual owners or occupiers of public works may be again referred to as showing another aspect of the mind of the Legislature.

II.—*Effect of Trade Effluents on Sewers and Sewage Purification Works.*

I think it right also to direct attention to an apparent difference between the provisions of the Public Health Acts and the Rivers Pollution Act in regard to the right of the local authority to refuse admission to the sewers of an injurious effluent.

Sec. 110 of the Public Health Act, 1897, only prohibits this if damage can be proved to the " structure " of the sewer, or if a nuisance is caused by the admixture of the effluent with the other sewerage. It is difficult to conceive circumstances in which nuisance could be proved.

Damage to the structure of the sewer would only occur in rare cases. On the other hand, Sec. 116 gives a wider discretion to the local authority, while Sec. 7 of the Act of 1876, as interpreted by the Courts, and Sec. 233 of the Burgh Police Act, 1892, gives them reasonably adequate protection in that matter.

My remarks as to the apparent conflict in regard to the obligation to take in trade effluents apply equally to this aspect of the question, and show the necessity for an amendment of the law, which will bring about uniformity. It seems to me that on both points the law calls for amendment and codification.

The only other point I desire specially to refer to is the effect of trade effluents on sewage purification works. This is specially important in a county such as Lanark, where the system of purification generally adopted is based on bacteriological principles, and consists of preliminary treatment in tanks followed by filtration. Works of this nature have been put down as being best suited to the ordinary requirements of a number of special drainage districts. In such districts, however—as Lanarkshire is an industrial county—there may be manufactories which produce an effluent which if introduced into the sewage works would at once destroy or seriously impair their efficiency. It seems reasonable that this should not be permitted ; therefore any amendment of the law should make it clear that protection is to be afforded to sewage purification works as well as to sewers. It need not be pointed out that in the generality of cases the damage to purification works would be much more serious than to sewers if a deleterious effluent were allowed to be introduced into them.

The Commission may desire to have a note of the decisions in the Scotch Courts on the subject of rivers pollution. I have prepared such a note of the more important cases known to me, and will hand it in if desired.

27464. You think the Rivers Pollution Acts may be enforced both as regards sewage and trade pollutions, but that they call for amendment so as to avoid the prolonged litigation that certain of their provisions give rise to. Could you enlarge upon that point as regards the prolonged litigation ? Do you not find that cases can be brought quickly to trial ?—Cases can be brought quickly to trial, Sir, but once brought to trial the Acts permit of dilatory pleas which are largely taken advantage of for the obvious reason that local authorities and other offenders, to put it quite frankly as they have done, prefer to spend a certain amount per annum in legal expenses rather than be put to the serious capital expense of putting down preventive works. It is a well-known fact, especially as regards certain local authorities, for whom I have some sympathy looking to the great capital cost involved in laying down purification works, that if they can have the thing delayed by litigation they take advantage of every step which permits them to carry on their proceedings. That has been our experience in Lanarkshire, and while we have succeeded in practically every case which we have brought, it is quite obvious, from the short summary which I give here, and also from the particulars which I can furnish if necessary, that something requires to be done to prevent the opportunity which is now afforded of unnecessary and prolonged litigation in regard to matters which are obviously and notoriously ones which could quite easily be settled with more expedition.

27465. Might I ask you, as regards Scotch legal procedure, after a case has been tried before the Sheriff-Substitute is evidence again taken before the Sheriff-Principal ?—No ; the evidence is not again taken before the Sheriff-Principal.

27466. Nor again at the Court of Session ?—Nor again at the Court of Session. The real point that I draw special attention to is the facility with which cases can be taken from the Inferior Court, that is the Sheriff-Substitute or the Sheriff-Principal, to the Superior Court by special case. There is nothing to prevent the defenders at every stage of the proceedings going to the Court of Session, and saying : " We want an opinion on this particular point." That, of course, can be carried to an absurd excess. Every single point in that litigation, however worthless it may be, and however much the Court of Session may say that it thinks it worthless, the defenders may bring to the Court of Session at every stage competently by special case and also incompetently by marking an appeal in common form. We have had cases where such appeals have been taken and then withdrawn just before hearing in the Court of Session. The expense to the appellants is only a few guineas and often several months delay is occasioned. My suggestion is that the matter should be dealt with as an ordinary litigation, subject to this, that there should be no appeal from the Inferior Court to the Superior Court, except on a final judgment, with this exception, which is a relaxation in favour of the defenders, that if there is any point of importance, such as a point that has emerged for the first time in this class of litigation, where the Inferior Court thinks it reasonable that the defenders should get an opinion from the Higher Court, they should be allowed to appeal by leave on that particular point otherwise that the case should be disposed of in all its stages by the Inferior Court, and an appeal should only lie to the Higher Court when a final judgment has been given by the Lower Court.

27467. Then, if I understand you rightly, at each stage of the proceedings it is possible to appeal to the Higher Court ?—That is so under the Acts, and it has been our experience. Cases have been taken at almost every stage. For instance, a case that is pending against two of the Burghs, Airdrie, and Coatbridge, has been before the Sheriff Substitute on several occasions, or before the Sheriff-Principal, specially appealed on a particular point to the High Court, judgment given in our favour, remitted back to the Sheriff-Substitute, disposed of by him in our favour, appealed to the Sheriff-Principal, disposed of by him in our favour, and now is under appeal to the Court of Session on a special case. That can go on *ad infinitum.*

27468. Can you tell us whether that is possible in England ?—Well the same provision, as regards a special case is apparently competent in England as it is in Scotland, but I understand that under certain court regulations, the stated case has been practically abandoned in England. An English lawyer would be able to give a more authoritative opinion on that, but I understand that it is the fact that the stated case is not so well known in England as it is in Scotland. Possibly the cases we have had have been exceptional ones where the local authorities whom we are proceeding against, in view of difficulties which I will refer to afterwards, namely, the cost of the works, do not wish to incur the heavy expenditure, especially when they consider that matters are somewhat pending as regards the best means to be adopted for purification, and they are trying to hang matters up so as to avoid the expense which they expect they must ultimately be put to, and for that reason they take advantage in the most astute way of every loop-hole which the Acts give them to delay a final judgment. Thus in one case three months delay was gained by an ordinary appeal being taken from a decision of the Sheriff-Principal to the Court of Session. This was dismissed as incompetent and the defenders then appealed on the same point by special case.

27469. Could you give us any idea as to what sort of points are referred to the Higher Courts ?— Well, yes, I could ; but Dr. Wilson, perhaps, could give the points better than I can.

27470. Take any one or two cases, and give us an idea of the sort of points they are ?—One point in Airdrie and Coatbridge was whether a stream was really a sewage drain or sewer. That was one point. Another point was whether they had a prescriptive right, and also whether a local authority could be held to be "causing to fall or flow or knowingly permitting to fall or flow," sewage, inasmuch as the sewage was being contributed by persons who, they alleged, had a prescriptive right to put it in. Another point was whether domestic sewage and trade sewage had to be distinguished. Another that a "ditch" was not a "stream." Appeals have been taken against orders of the Sheriff allowing a proof, remitting to a Reporter, dismissing the case on the defenders' failure to appear, and allowing the County Council the expenses of a proof, where no order was granted.

27471. You mention that here ?—And questions of expenses : questions of remits to engineers, and the right of the county council to prosecute instead of the district committee, which we have in Scotland ; every conceivable point that occurs to an astute lawyer who may know perfectly well that there is no foundation for his case, but who uses the special procedure to delay matters. I am dealing with the question generally, because as regards the cases with which we have had most difficulty, namely, pollution from local authorities, it is a notorious fact that all the burghs that we have gone against are in fact polluting, and nobody will deny it, they are doing nothing, it is an obvious fact, but they are taking advantage of everything ; they can appeal in fact on every single point, even a step of procedure ; *e.g.*, whether the Sheriff was right to allow expenses at a certain stage, they can appeal that to the High Court. I also suggest, as possibly worthy of the consideration of the Commission, whether there should be in Scotland even the possibility of taking a case before the Sheriff-Substitute, and also on an appeal to the Sheriff-Principal. That is to say, in Scotland we really have three courts. I do not know what the law of England is, but I imagine the County Court in England is a Court of Summary Jurisdiction with appeal to the High Court ; there are two courts in England, and three in Scotland. I am not sure about the English law, but I should think that is so ; we have thus three courts in Scotland as against two courts in England. Now there are many cases in Scotland where questions that are more ministerial than legal are directed to be sent to the Sheriff-Principal rather than to the Sheriff-Substitute and I suggest that it is worthy of consideration whether as proceedings under these Acts are more an inquiry than a legal proceeding it might not be sufficient, if the Sheriff-Principal was ordained to take the case, in the first instance, to the exclusion of the Sheriff-Substitute. That would save one court in Scotland.

27472. Would not that be very unusual ?—It would be unusual in a question of pure litigation ; it would not be unusual, but rather according to precedent in a question of inquiry more than litigation.

27473. What area does the City of Lanark comprehend ? Is the City of Glasgow under special conditions ; it has its own Sheriff-Substitute, I know ?—The Sheriff of Lanarkshire is also the Sheriff for the City of Glasgow.

27474. But not the Substitute ?—The Substitutes are the same. There is in Lanarkshire one Sheriff-Principal with four or five Substitutes, each Substitute having his own particular district My evidence deals exclusively with the County of Lanark ; exclusive of the City of Glasgow.

27475. (*Colonel Harding.*) Exclusive ?—Exclusive of the City of Glasgow.

27476. You have no authority over the City of Glasgow ?—No, we have not, because Glasgow is at the bottom of our jurisdiction. The river enters Glasgow from us, therefore we would have no jurisdiction against Glasgow. If Glasgow had been above our jurisdiction then we would have jurisdiction over Glasgow in respect that we might be able to call upon Glasgow to cease polluting.

27477. (*Chairman.*) Does your jurisdiction comprehend practically the Clyde and its tributaries ?—Yes.

27478. And no other river ?—No ; a very, very small portion of the county drains into the River Tweed, but we comprehend the Clyde and its tributaries, and Lanarkshire is to that extent on another aspect of the question, somewhat unique, because the county council being the authority for practically the whole of a watershed, is in a position to deal with the question of pollution in a way that comparatively few other county councils in Scotland are. The county council themselves are not polluters and cannot be because they are not directly the sanitary authority. They are, therefore, in the position of being able to call upon the burghs which are outside their jurisdiction to cease pollution, and they are also able to call upon—although it may seem rather strange—what are known in Scotland as the district committees, who are the sanitary authorities in counties, also to cease pollution. The district committees are partly composed of local members of the county council and partly of representatives of the parish councils.

27479. Then below Glasgow, of course, it ceases to be Lanarkshire ?—It ceases to be Lanarkshire. Well, there is a very small portion of Lanarkshire below Glasgow, an entirely detached portion of the county, called South Govan, which need not enter into the question at all. It is a small area, but you may practically say we have no concern with the City of Glasgow or any area below Glasgow. Glasgow Corporation are an authority by themselves, they have special Acts of Parliament, as the Commission are aware, and the only connection that we have with Glasgow is this, that our action to some extent has been prompted by the fact that we know the great expense to which Glasgow is going to on the question of river purification, and we also know the right, that Glasgow, as the local authority, will have to call upon all the upper authorities to purify, and we are really taking action in advance of what Glasgow would inevitably do if we had not stepped in. I might also mention, as regards Glasgow that a small portion of the county in the immediate environs of the City of Glasgow, is, by arrangement with the county council, in the Glasgow Purification Scheme, and is entitled to drain into the Glasgow sewers and pays, subject to certain deductions, the same assessment for purification as the City of Glasgow does.

27480. What is the connection between this Glasgow Purification Committee and the Clyde Trust ? Any ?—None whatever.

27481. None whatever ; the Clyde Trust have nothing to do with it ?—Nothing whatever. The Glasgow Sewage Works is entirely a matter for the Corporation of Glasgow. Even we in Lanarkshire, who pay a considerable sum, and the Burghs of Govan and Partick and the City of Renfrew and the Borough of Rutherglen, and one or two other authorities I think who contribute substantial sums towards the cost of these works, are not represented on the Glasgow Sewage Commission ; it is entirely a matter carried out by the Corporation of Glasgow in their corporate capacity, under special Acts of Parliament.

27482. Are the questions which are raised before the courts—Sheriff-Substitute and Sheriff-Principal and the Court of Session—questions of fact or questions of law ? Would you be helped, in other words, by the appointment

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of a central board to determine questions of fact ?—Well, my opinion is very strong indeed in favour of the institution of a central board.

27483. I suppose at present those courts determine questions of fact ?—They determine questions of fact, and I mention it because I think it confirms the opinion of the Commission as being the right thing to do by instituting a central board. Assume one case against a burgh, elaborate proof is required, an expensive proof, going into the whole question of the quality of the sewage from the polluting area, the means by which that sewage can be purified and all other questions of fact ; we get a decree against this particular burgh. That is all good and well. Two years afterwards we start exactly the same question, dealing with exactly similar circumstances, as regards another burgh ; we have to go through the same elaborate proof. Take the question of trade pollution also ; we deal with one work ; we go through the same proceedings, proving the nature of the effluent, the means by which it may be best disposed of, and the legal questions—these are important, the legal questions affecting the rights of the pollutor and the duties of the local authority—we get a decision in our favour ; a year afterwards the same question crops up, if these people choose to be dilatory and not to acquiesce—we say it is no use fighting ; this thing was settled in the previous case. But if they do not acquiesce the same thing has to be gone into. Then further than that, when the works are ordered by the court a remit is made to a man of skill to see the works carried out which he sees done ; after some time another case arises at the same works, a fresh man is appointed with a fresh mind with different views possibly ; the same thing has to be gone through. Now I think on the whole the suggestion that there should be a central authority to deal with questions of fact, leaving it to a court to decide questions of law and to give effect to what the central authority recommends as reasonable in the circumstances, would be a tremendous advantage and go very very far indeed to solve the difficulties which we have experienced, both as regards delay and also as regards expense.

27484–6. I think this might be a fitting opportunity for putting this question ; do you think there will be any difficulty in the central board existing in London for the three kingdoms ; for England, Scotland and Ireland. It opens this question ; would it be necessary to have a Board for Scotland at Edinburgh ?—If my opinion personally is asked, and is of any weight, I see no reason whatever why the authority should not be a central authority in London for the three kingdoms, and I see great reason why it should, because a centralised board is generally a strong board. If you dissipate the energies of a board such as is contemplated and give them powers, and form separate boards for the three kingdoms, then obviously you do not get such an effective board in each kingdom. I am quite heterodox, Sir, but my opinion, not only on this question, but on other questions, as regards central boards in opposition to decentralisation is strongly in favour of centralisation. I am speaking as a Scotsman, with Home Rule proclivities if you like, but that is my opinion very strongly. I think it would be a very great mistake indeed if you gave us a semi-effective body in Scotland, where we are parsimonious and where we do not spend too much money rather than have an effective board here.

27487. (*Chairman.*) We need not enter into the possible administrative difficulties which, under the English Local Government Board, might create some trouble, but I am very glad to hear your opinion in order that we may press on the authorities the necessity for one central board. Is there any other point connected with the legal proceedings that you would like to allude to before we pass on to the second heading ?—No, I think not, Sir. Well, one other suggestion—perhaps it is more administrative than legal—dealing with what I have just said as to the necessity in every case of dealing specifically with individual cases and telling them what to do and what not to do, whether it might not be advisable, as I think it is, that a local authority should have the power of making by-laws regarding the methods which traders or local authorities should adopt for obviating pollution and also regarding other sanitary matters such as the additions of connections to public sewers, etc. Just now we have to deal with every case specificially as it arises and the local authority should have power, as they have under the Public Health Acts in regard to matters of even more importance, to make by-laws which would be of general application and which would be generally known and this power to that extent might considerably facilitate matters by informing the public what they should do in certain events. To take for instance the case of a trader proposing to put down a new work, the by-laws would specify what he should do by way of avoiding the possibility of his offending against the law.

27488. Which rather brings in the question of standards, does it not ?—Well I expect the question of standards would have to be considered in connection with that ; in other words, each local authority would not be entitled to lay down by-laws which would be laws for itself ; it might be oppressive.

27489. Would it not be well to leave that in the hands of the central authority—the question of standards ?—The question of standards certainly should be left in the hands of the central authority ; all I suggest is, given the central authority laying down standards, whether the local authority should not be entitled to make by-laws which would be really operative as regards bringing the law, based upon these standards before the public, and making it obligatory upon them to conform. The point really is, deal with the question generally rather than leave it to each individual case to be dealt with, which is unfair to the offender, more even than it is to the local authority, because a man might quite innocently lay down works not knowing about what was required of him with regard to purification and might be subjected to very heavy expense when he was found to be an offender.

27490. (*Secretary.*) I think the sole case Mr. Munro has in his mind is this ; in the Third Report of the Commission it was recommended that the manufacturer should have the right to put his stuff into the sewers, subject to regulations made by the local authority and confirmed by the central authority. There would be rules and regulations as regards the conditions which the manufacturer must attend to before he can put it into the sewers ?—That is the type of thing ; that is what is in my mind.

27491. (*Chairman.*) You allude to the pollution of waters which flow out of mines ; what have been often called ochre waters ?—Yes, Sir.

27492. And you state that these at present are not regarded as polluting waters under the Act. You would wish these to be brought in under the same heading as ordinary sewage pollution ?—Well, what I suggest is that the matter is one worthy of the consideration of the Commission. I am naturally in a difficulty now, because I am dealing with a practical question on which I thought Dr. Wilson would precede me, but I do conceive of a case such as I have known where water was taken from a mine, direct from a mine, and let flow into a stream, which to my mind was obviously a polluting liquid, and owing to the exemption in the Act they were, in my opinion as a lawyer, entitled to get free.

27493. We have had evidence this morning relating to that very point as regards the Yorkshire rivers. It appears there are effluents from mines in which the water is pumped up and flows into a stream, and the mining is carried on necessarily under the condition of getting rid of its water. I think that is simple enough ; that might be brought under the Act but a case has been mentioned in which a disused mine produces precisely such water which overflows and gets into a river. Would not that be a difficulty ?—The question of a disused mine is difficult because it is a natural flow.

27494. It comes to be a natural flow into a river ?—My suggestion has reference to a case where the natural flow is interrupted and the water is taken from a mine by artificial means, and is really, to the layman, a polluting liquid.

27495. And a polluting liquid which is necessary so long as the mine is carried on, unless indeed it is purified ?—It should be purified. I say it is no reason why it should not be purified, because it is part and parcel of the working of the mine. This is an obligation every mine-owner knows he must undertake when he starts mining, and if he neglects it I do not see why the exemption should continue. I also refer to the fact of the question of innocuous discolouration which is very much the same point. Again it seems to me, not as an expert, but as an ordinary observer, a little difficult to understand what was in the mind of the legislature when they exempted water which is very highly discoloured, discoloured to such an extent that it changes the whole aspect of a stream. Why that should be exempted from pollution in the ordinary sense of the term is to me rather difficult to understand, and I instance a case where my life has been troubled for years through a gentleman whose estate was ruined through a highly-coloured discharge being allowed into a stream which ran through his policies. I have every sympathy with the gentleman, and for years and years the thing has gone on, and we practically could do nothing, and he could not understand why we could not do anything, because to him it was a most awful pollution, it may be because he was a man of æsthetic tastes.

27496. I think, under one of the former Acts, the depth of the colour is a criterion ?

27497. (*Secretary.*) The Act simply says: "Innocuous discolouration;" I do not know whether that has been interpreted ?—I know of no case; there is no case to my knowledge.

27498. (*Mr. Tatton.*) You would have to prove it was innocuous before it could be exempt ?—If we could prove it was a noxious liquid we would get hold of it, but the mere fact of discolouration being exempt by itself throws a tremendous onus of proof on the prosecutor because you go into court with the presumption that discolouration is not a pollution. It may seem strange but that is so. The ordinary judge will say: Well, but this is only discolouration; the Act says that discolouration is not a pollution, therefore you must prove that it is a noxious pollution. Now there is the difficulty which the prosecutor meets in this case.

27499. Was there no solid matter at all in this liquid ?—Nothing to speak of. I think Dr. Wilson has got samples of something like the thing here; he will be better able to speak to it; I cannot, of course; I only put these two points which have occurred to me in practice of dealing with what the public take to be pollution.

27500. (*Chairman.*) Coloured liquids and ochre from mines ?—And water from mines.

27501. Might I just ask you in passing whether there is much coal washing goes on in Lanarkshire ?—Oh, yes, a great deal.

27502. And do you find that your object is affected ?—Yes. Dr. Wilson will be able to speak to that. I am bound to say that on the whole we find the colliery owners not unreasonable. The great difficulty we have is, not in getting them to put down plant to purify, but to get them or their employees to keep that plant in working order. The amount of correspondence we have with them is immense, occasional pollutions taking place; a man gets careless or out of sheer mischief, rather than give himself trouble, when there is a spate on in the river, simply shoves the whole thing into the river.

27503. Then further on you speak of the obligation of the local authority to provide for the reception of trade effluents. It is an enabling, and not an obligatory provision ?—I think I could perhaps shorten my evidence on that point; subject to this precis being printed, I can explain it in a word. There seems to be a difference between the Scots law and the English law as affecting the respective countries. As far as I can make out there is an obligation in England upon the local authority to provide sanitary works which will effectually convey the whole drainage of the district. Now in Scotland in counties, as I read the Acts, there is no such obligation. There is, however, in burghs in Scotland an obligation similar to that which exists in England under the Public Health Act, 1875. There are the same words used: "Effectually drain." The peculiarity is burghs are under the Public Health Act and the Burgh Police Acts and where they stand, if the question were tested, I cannot at this moment presume to say for the decisions in Scotland appear to have decided that the two Acts are to be construed separately and that they provide two alternative codes. But certainly in counties there is no obligation on the local authorities to lay out a drainage system that will do anything more than satisfy the requirements they think reasonable, they being the executive authority which can only be taken into court, as I read the Acts, if a complaint is lodged by the Local Government Board, in which it is proved that the want of proper drainage is injurious to the sanitation of the district. Now anyone that tries to prove that the mere fact that all the trade effluents, or the sewage effluents, not being accommodated in drains and sewage purification work constitutes a nuisance in the ordinary sense of the term, will have a very difficult piece of work before him; so I say with some confidence there is no obligation in Scotland upon the local authorities in counties to do more than they themselves think reasonable. When, however, we come to the law, as affecting the right of the individual in the district to claim a connection with the sewers of the local authority, a difficulty arises in my mind on a construction of the Public Health Acts, taken by themselves, or as read along with the Rivers Pollution Act, because I read Sec. 110 of the Public Health (Scotland) Act, 1897, as implying that the owner or the occupier of premises is entitled, given the discharge from his works is not such as to cause damage to the "structure" of the sewer, to a connection with the sewers of the local authority. Now the question that arises there, if the sewer of the local authority is not sufficient to permit of the connection being made is, "Is that owner entitled to insist upon the local authority enlarging at the expense of the rest of the district, the sewer, or else constructing a new sewer to accommodate this particular discharge ?" Standing on the Public Health Act alone, and reading Sec. 110 alone (I think it is a badly drafted section, and the man who drafted it admitted it is a badly drafted section), but standing on that section alone there is a great deal to be said, especially as the section proceeds on the obligation of the owner to pay, that the owner is entitled to the reciprocal right to connect notwithstanding the size and the capacity of the sewer. But when you come to the Rivers Pollution Act you will find there is a discretion given to the local authority provided the sewers are only of sufficient size for the requirements of the district to refuse to admit the trade discharge.

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27504. And it is they who determine that size ?—It is they who determine that size. Now the question that has to be considered, and I think it has already been considered by the Commission, is whether, in an event such as that, the local authority first should be entitled in all cases to refuse to admit a discharge, which their sewers, as constructed for the ordinary requirements of the district seems insufficient to meet, or whether they should be bound to admit the discharge from every work in their district with the obligation upon persons who would acquire extra facilities over and above what is ordinary, to make an additional contribution, over and above their contribution by way of public rate, to the expense which the local authority is put to through their work. I consider myself that the latter is the reasonable suggestion to make if there is to be a new law on the subject.

27505. But who would assess this extra contribution ?—The local authority would assess this extra contribution, with a right of appeal as is legitimate in all cases to the courts or to the central authority if necessary.

27506. (*Secretary*). That is dealt with in the Third Report of the Commission ?—As I say, I have taken the liberty of referring to the law in Scotland, not by way of explaining anything further to the Commission than they already knew through the evidence given by Mr. Murray, of the Local Government Board, but by way rather of accentuating Mr. Murray's evidence on the law in Scotland, and making it perhaps a little more pointed from the point of view of an actual administrator of the law than Mr. Murray could, and in the hope of emphasising what I consider a very reasonable proposition on the part of the Commissioners, as contained in their Third Report, viz., that on the whole the balance seemed to be in favour of the view that the local authority should accomodate all discharges in their district, and that it was reasonable in that event that the persons so accommodated, notwithstanding that they paid equal assessment along with other ratepayers in the district who derive no particular advantage from drainage connections, should also be asked to pay an additional contribution in respect of the additional facilities which were being conferred upon them. I should also explain, as rather corroborating

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what I say, reading the remainder of the sections of the Public Health Act of 1897, especially Sec. 120 and Sec. 116, bears out my view. You find, for instance, Sec. 116 begins, "distilleries and kindred works;" and goes on to say that they are themselves, before introducing their discharge into the sewer, to purify it. That bears out my view that it is not unreasonable that the owners of work producing injurious discharges should be asked to pay something in addition to the cost of the ordinary works of the district.

27507. (*Mr. Tatton*). Would that apply to the outfall works as well as to the intercepting sewer?—I think that is a question that certainly must not be overlooked, and I deal with it later on in my evidence. If you find that the introduction of a particular discharge costs the local authority additional money by way of purification, then I think that is an element that should quite properly be taken into account in estimating the value of the facilities afforded to the particular works.

27508. (*Chairman.*) In other words, the local authority can compel the manufacturer to connect with the sewers but the manufacturer cannot compel the local authority to construct the sewers; is that not the long and short of it?—At present.

27509. At present?—I think on the whole that is the sound view, reading the Public Health Act and the Rivers Pollution Act together, which the courts have done, rightly or wrongly. I say the courts have apparently read the Rivers Pollution Act into the Public Health Act. That is the view which the courts take as far as I can construe the cases. Now, of course, a view such as that may or may not, in my opinion it does, inflict hardship, or at least is capable of inflicting hardship, on certain traders.

27510. Then you suggest in your recommendations that the local authority should have the power to refuse to accommodate trade effluents which their sewers, as constructed for the ordinary requirements of their district, are incapable of accommodating; or that they should only be bound to receive such effluents on payment of an adequate return for the extra expense caused over and above what the ordinary requirements of the district call for?—And my own personal view is in favour of that alternative which is really the recommendation of the Commissioners in their Third Report. I point out as significant that under the Burgh Police (Scotland) Act, if the sewers of the local authority are not sufficient to accommodate trade discharges, then in that event the owner or occupier of the trade premises is allowed an abatement of taxation to the extent of three-fourths; he only pays on one-fourth, showing that in that particular Act the mind of the legislature was that the obligation to pay involved a right to obtain a benefit if the benefit could not be obtained, then there should be a relaxation of the obligation to pay.

27511. Then again you point out that there is an apparent difference between the provisions of the Public Health Acts and the Rivers Pollution Act in regard to the right of the local authority to refuse admission to the sewers of an injurious effluent?—Yes; that is practically very much the same. There seems to be a kind of conflict between the Public Health Acts read by themselves and the Rivers Pollution Act. The Public Health Act provides that the local authority, before refusing admission to their sewers, must prove that the discharge is one that will cause damage to the "structure" of the sewer, "structure" being the word used and inserted for the first time in 1897. Why, I do not know. Under the Rivers Pollution Act I think the local authority requires to prove a great deal less. Now I think that is a question that requires to be looked very seriously into, because the difficulty of proving damage to the "structure" of the sewer seems to me immense, and also the difficulty of proving the other condition which would prevent the introduction into a sewer, namely the liability to cause nuisance. Personally I can hardly conceive the case where the introduction of any particular effluent into a common sewer was going to cause nuisance.

27512. But you would extend the provision so as to make it apply to damaging the sewage works, thus preventing the efficient purification of sewage?—Yes, and that is really my last point. The law of Scotland seems to me as far as I have been able to understand it, to give no specific protection as regards damage to purification works through the introduction of an effluent, that is an effluent which is distinguishable from other effluents that the sewage purification works were designed to meet, and which, if allowed to be introduced into a sewage purification works, might in my view, although again it is a question for experts, practically ruin the sewage purification works. In other words, the damage possible to be caused to a sewage purification work through the introduction of an element alien to the ordinary effluents of a district, which the purification works for the particular locality were designed to meet, might cause very much more serious damage than any effluent introduced into an ordinary sewer.

27513. In structural damage?—In structural damage. A sewer might very much more easily be put right than expensive purification works.

27514. The Commission are much obliged to you for your evidence, which is extremely valuable.

Dr. JOHN T. WILSON, Medical Officer of the County of Lanark, examined.

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27515. (*Chairman.*) You are County Officer of Health for Lanark?—I am.

27516. That, I think, does not include Glasgow?—It does not, nor the burghs situated throughout the county.

27517. No; simply the county itself?—The county. Of course, so far as rivers pollution is concerned, it is quite easy to understand our position if you refer to p. 5 of the report which I have submitted. I there divide really the county for administrative purposes under the Rivers Pollution Prevention Act in this way, that I speak of a north-western portion as the Glasgow area, and the reason why I eliminate that is that the Glasgow Corporation, by their Sewage Acts, deal not only with the pollutions from the Glasgow City area itself, but from adjacent and contributory areas. Thus you have the Burgh of Patrick on the one side, the Burgh of Govan on another side, and then you have no less than three county areas, in Lanarkshire, Renfrewshire and Dumbartonshire, all contributing sewage to the Glasgow Purification Works.

27518. But is not Renfrewshire further down the Clyde than Glasgow, and Stirlingshire still further down?—They are, Sir; they are below. We have a small portion, two small portions, just adjacent to the Glasgow boundaries. One Mr. Munro has mentioned as the South Govan area, the other we call the Rutherglen area. Well, you see, in those Glasgow Corporation Sewage Acts they have quite a number of contributory areas outside the city area; therefore, for the administration of this Act we say this is to be called a Glasgow area, and so far as pollution is concerned of the River Clyde it is being dealt with by the Glasgow schemes, and for the rest of the county we are administering the Rivers Pollution Acts. That is to say, that where you have a large number of burghs with separate administration, all polluting streams, either the Clyde or its tributaries, we are the authority there under the Rivers Pollution Act, because it is our part that is affected.

27519. Might I put this question to Mr. Munro; but I may put it to you, and possibly Mr. Munro will consider the answer too; would you think it an advantage to centralise still further and include Glasgow in the Lanarkshire area so as to make one watershed?—Well, Sir, we look upon it really as one watershed at present.

27520. Does it work harmoniously as one watershed at present, or could it be made to work more harmoniously if you were to become incorporated with the actual Glasgow authority?—I do not think it would make any difference, Sir, because the pollutions arising from the City of Glasgow and those neighbouring authorities, are being dealt with—that is to say, there is a scheme for preventing pollution from these—if they had done nothing, then I can see the need for some larger area—that is to say, going down the estuary of the Clyde, down to Renfrewshire and Dumbartonshire—but seeing the great work that Glasgow and the neighbouring burghs have done and are doing their duty, then the need for a larger area does not apply now.—(*Mr. Munro.*) It might be of interest to the Commission historically if they were informed of the fact that the question put by you, Sir, was considered very carefully more than twenty years ago as to whether there should not be a joint authority for the watershed of the Clyde, and after careful inquiry and reports by eminent authorities it fell through; and on the whole, apart from the question of expediency, questions of local considerations, I think, would militate against any proposal of a joint board.

27521. It just occurs to me that conceivably the City of Glasgow might at some time or other grumble at the state of the Clyde before it reaches it; it is not at present, I admit, practical politics, but it is conceivable that Glasgow might purify its effluent to such an extent that it would be as pure as the Clyde which reached Glasgow, in which case they might have more reason to grumble at the effluent from the upper area of the Clyde?—What you have said is what we know will happen. We are perfectly well aware of the fact that if the County Council of Lanark do not succeed by their efforts in obtaining the purification of the Clyde before it reaches Glasgow, and Glasgow has purified its own portion of the river, they then will call upon us to purify the upper reaches, and if we fail in doing so they will have the right that the law gives them of calling upon every local authority in the upper reaches to take steps to purify.

27522. Then you consider the present administrative district satisfactory enough?—Unless we fail, absolutely fail, in the efforts we are putting forward. Then the present administrative district arrangements, owing to the peculiar circumstances of the county council being a non-polluter itself and therefore having apparently an open mind on the subject—and the fact we are the authority for the whole of the watershed with the exception of Glasgow, the one person that can complain against us—I think the thing will work out all right if we succeed; if we do not succeed, then some such contingency as you refer to may have to be faced.

27523. The reason I asked the question is this, that part of the recommendations of the Royal Commission is that watersheds should be provided for certain parts of Great Britain. A watershed for this particular area would include Glasgow; you think it would work well enough if the arrangements are left as they are at present?—(*Dr. Wilson.*) I am quite sure of that, Sir, and with reference to the remark if the water reaching Glasgow was worse, say, than their own effluent, I would refer you to the diagram on the last page of my notes. You will see there how very much worse the River Clyde is in the City of Glasgow than it is above Glasgow.

27524. I am quite aware of that, but I was looking forward to the possibility in the future?—Oh, yes; what I think might happen in the future is this: as the County Clerk says, this might fail. Then the City of Glasgow would have to deal with offenders further up the river. But there is also this might happen: the amount of purification effected by the city schemes might not be looked upon by these riparian proprietors further down the Clyde as satisfactory; they might say: "You are only purifying to a small extent just now; you must go on and do more."

27525. That is perfectly possible too?—Yes.

27526. Well, shall we turn now, Dr. Wilson, to the various kinds of effluents?—Yes, Sir.

27527. You mention effluent from lead mining?—Yes.

27528. Coal mining?—Yes.

27529. I suppose that very largely amounts to dilute acid, or what is it: is it suspended matter?—Well, in lead mining just now we are only concerned with suspended matter. You see the acid only comes into play by the roasting of the ore; it is a clear liquid, that is to say, there is no galena in this; they take care to take all the galena, but in the crushing of the galena, other mineral material has been ground up with it, this means silicious material. The question might be asked what amount of purification should they effect; what amount of suspended matter would we really look upon as passable; fish life is not affected by it. The Commission's test for sewage would not perhaps apply and yet we would like, I think, the Commission to consider whether for pollution such as this there should be any standard fixed, and if so, what it should be.

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27530. Is there any metallic substance in solution?—No lead in solution; the galena does not dissolve; it is simply silicious material.

27531. (*Colonel Harding*). I suppose you would consider it an objection that a person should tip a cart-load of fine ashes or anything of that kind into the stream?—Oh, surely.

27532. Is not this of that character that it would cause a silting up of the stream?—No, Sir. The suspended material is so very fine that it will run for a very long distance without any silting up. The amount and the character of the suspended material are such that it can run right down the clear water to the River Clyde itself without causing any silting up.

27533. (*Mr. Tatton*). Would it settle readily in tanks?—Yes. They do settle it to a certain extent, but still the very finest does come away with the effluent.

27534. (*Colonel Harding*). Would you not consider it yourself an objectionable thing that an effluent should be turned into the stream containing a considerable amount of suspended matter even if such suspended matter were not putrefactive?—Yes. We dislike it but we have never thought of contesting this in a court of law for this reason, that we have had no complaints. The only complaint we had referred to the roasting of the ore, where it was alleged by the fishermen when they got some hundreds of dead trout that this was due to the discharges from the smelting works. Owing to an action which was raised against them at common law they have discarded that operation and the ore is being roasted elsewhere, so that part of the complaint has gone.

27535. (*Chairman.*) Is there no danger of the small particles of galena being washed over the fields and being eaten by cattle?—No.

27536. Nothing of that sort?—No; galena is so valuable.

27537. They take care to get it out?—Yes.

27538. Then as regards coal mining; is there much coal-washing?—As Mr. Munro has told you the coal masters do very well by us. At first we had considerable difficulty and we had some litigation, but for some years now we have had no reason to complain. The great point there, and it should be enforced here, is use the water over and over again; in other words, diminish the amount of production of polluting material. And it is so easy. You see how clear the liquid there is. (*Exhibiting sample in bottle.*) That is just by standing. (*Witness shook the bottle*). It becomes as black as ink. But it would certainly greatly help us, I think, in the way of controlling pollution if, as Mr. Munro has suggested, we had some sort of regulations. First of all, if a coal washer is going down you cannot go to the proprietor and say: "You must do this or you must do that." You have to wait until the works are constructed and the pollution takes place. You have no right to make any complaint till you actually get the pollution. I think if there were by-laws or regulations by the central authority that the coal washer was to lodge plans or make some intimation to the Rivers Board that he was going to do such a thing, then he would get such advice as would prevent the pollution occurring.

27539. I understand it has been very profitable to save the washing from the coal?—These little particles used to go into the stream; now they use them for the boiler furnaces; it pays them undoubtedly.

27540. When you speak of ammonia works do you mean coke ovens?—Not necessarily. I mention the different kinds of works. In our areas they were first introduced with the ordinary coal gas works for the manufacture in connection with the towns' supplies, and then they were introduced to the iron blast furnaces. I think they are the largest producers now of ammonia. Then we have them on coke ovens, and then also in connection with what is called gas producer plant of the Mond type and the Duff type.

27541. Is that used in Lanarkshire too?—Yes. And this is one of the pollutions I bring specially before the notice of the Commissioners; an effluent most difficult to treat, most difficult to deal with. Put a fish into say 10 parts of that with 100 of water and it will squirm and jump out of the dish. You see it robs the water of all

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oxygen, besides having a very powerful irritant effect owing to the phenols.

27542. Is no step taken to remove the phenols ? Of course the water is scrubbed for ammonia salts, but does the tar not contain the chief quantity of the phenols, some suspended solids in the water ?—No, it does not ; we get very large quantities of phenols. We have analysis available, but the amount of phenols in that spent liquor might vary from 70 up to 100 parts per 100,000, and I once asked a firm who manufacture disinfectants, and I think even Calvert's people, could they make any use of this liquid—it seemed a pity to have such damage—but they replied : No, they saw no way of utilising the phenols.

27543. Too dilute ?—Yes ; and it is extremely difficult to treat. So far we have been successful except in one work. You see in the coal gas works they have the coke, live coke, on which they can spread the spent liquor. That evaporates it. If you go to the blast furnaces they have lots of gas to spare as a rule and they can evaporate it. Some do it in their ordinary steam boilers. If you go to an oil work the spent shale comes hot on to the bing. The heat there evaporates it and what gets away from it goes through the bing. But in the like of a work such as a steel work, where they provide a Mond or Duff plant, to manufacture gas for power purposes, then they require all the gas for their own industry ; they have no gas to spare and it would cost a great sum of money to try to evaporate it. If then there is no old mine to run it into it is a serious business.

27544. Is it not possible to use it more than once ?—Well, they do utilise the water more than once ; that is to say, the water that contains acid for taking up the ammonia ; they use that over and over again, but there is always a certain amount that they cannot use over again.

27545. We were told that it largely consisted of cyanides ?—The spent liquor ?

27546. The spent liquor contains cyanides as well as phenols ?—That is not our experience at all events ; it is the phenols that we look upon as the polluting substances.

27547. Of course, these are inimical to bacterial life ?—Exactly ; and in illustration of a point raised by Mr. Munro, and it is a point too with which the Commission's own Report does not quite tally ; you say you have had no experience of any sewage plant not being able to deal with trade wastes ; well, Sir, if you have a small town of say 5,000 inhabitants, and you have a large gas work supplying that town and neighbouring towns, and all the spent liquor is discharged into the sewers of that 5,000 town, what then happens to the biological processes ? The volume of the spent liquor is such that it at once upsets the septic tank and the filters, and the whole thing goes wrong.

27548. (*Colonel Harding.*) Would not that simply mean that some additional process would have to be undertaken before the filtration ?—Well, but, Sir, what process could you suggest that would deal with spent ammoniacal liquor in such a way as to rob it of these phenols ? So far as I am aware there is no method yet devised that would render that liquid innocuous to germ life.

27549. (*Chairman.*) I think, as far as we know, the question has not been that the substance cannot be purified, but that it requires a very large amount of ordinary sewage to work it in with. For instance, in Manchester they do manage to get rid of such liquor ?—Oh, that is so, and when you go to the City of Glasgow, where they have got chemical precipitation, first of all there is a large admixture of ordinary domestic sewage, and, secondly, when it goes to the sewage works it is not a biological process but a chemical plant. It all depends upon the amount of admixture. If you have a large gas works going into the sewage of a small town and they are depending upon the biological process, septic tanks and filters, it upsets it. We have had that experience at Uddingston.

27550. You think that is a fit subject for investigation ?—I do, Sir.

27551. The sentence to which I think you allude is : "All the trade effluents of which we have had experience interfere with or retard processes of purification to some extent, but we are not aware of any case where the admixture of trade refuse makes it impracticable to purify the sewage upon land or by means of artificial processes, although in certain extreme cases special processes of preliminary treatment may be necessary ?"—Then I refer to an extreme case in my first report, not this second report, but my first report. There I deal with a sewage scheme that was completely upset, and where we had to go to the gas manufacturer, and say : "You must take your liquor out of here."

27552. We should admit that, of course ?—Yes.

27553. Might I ask you at this stage whether there is any association in Lanarkshire or any private works which would give facilities for experiments of this nature ?—There is, Sir, no association, but I have no doubt whatever that there are numbers of works that would give you facilities. Take, for instance, the Mossend Steel Works, where they are serious offenders just now, and where they have not been able to devise any economical method of abating the pollution.

27554. And they are willing to do it ?—I am sure they are.

27555. Then coming to paper-making, there are a good many paper works I know in Lanarkshire ?—Well, the colouring material is the chief difficulty there. The suspended matter can be taken out without great difficulty, but when you come to make red paper you have a liquid like this remaining—(*Exhibiting sample in bottle.*) Is that to be considered a pollution ? If you apply your oxygen tests I do not think it will be looked upon as a serious pollution at all, but, as the County Clerk has said, that amount of colour going into a small stream has a very bad effect on the public mind.

27556. Would that be removed by chemical precipitation ?—Yes. At the print works they have used sulphate of alumina, and if you could imagine these colours blended together, then treated by sulphate of alumina that is the first result.—(*Exhibiting sample in bottle*).—You get a certain amount of colouring thrown down, it goes into ponds and that is the final effluent.—(*Exhibiting sample in bottle.*)

27557. Which is respectable ?—Yes, it is, still we would like better if the Commission could devise some method of better dealing with it. But they spent a considerable sum of money in putting down that plant and in keeping it up.

27558. Do you notice any difference between the manufacture of rag-papers and *esparto* papers, where the soda is recovered, and brown papers, where the treatment is with lime which is not recovered ?—We have no difference really in our experience ; the lime really is not allowed to escape. It does not matter. For instance within one large works, the Clyde Paper Mills, where they use *esparto* largely, there is no lime allowed to escape.

27559. But I understand the materials for ordinary brown paper and packing papers are extremely dirty to begin with, and that they are treated with lime, which is, of course, of small value and not worth recovering ; does not that reach the sewers ?—No, it does not. In the Clyde Paper Mills, where they use lime, this is the ultimate effluent.—(*Exhibiting sample in bottle.*)—That is what we are asked to take into our sewers.

27560. (*Colonel Harding*). How are the matters which Sir William refers to eliminated ; is that by settlement ?—First of all they try to prevent any lime from getting into the effluent that they can help ; if there is anything can be shovelled out it is shovelled out, but they also have a little bit of a settling pond. Their chloride of lime, for instance, they need allow nothing of that to escape ; they simply get the chlorine taken out into their bleaching liquor and then shovel out the remaining spent lime.

27561. (*Chairman.*) They bury it, I presume ?—They cart it away, Sir.

27562. Pretty much the same remarks apply to calico printing, do they not ; that the water is very deeply coloured by calico printers ?—Yes.

27563. And does it not pay them to save their Turkey red ?—It does not. They have no way of recovering colour ; where, in a paper mill, the colour is associated with the pulp then the sediment is taken out and pressed and used over again, but in the print work you see it is not so associated.

27564. No, it is simply run into the rivers ?—Yes.

27565. Sulphate of alumina precipitates it fairly well, does it not ?—It does.

27566. So that would admit of purification of effluents containing spent Turkey red ?—Yes. Of course, what we are really concerned with in the like of this work is what restriction we should put on them in admitting it as a trade effluent. For instance, from the Clyde Paper Mill this goes into our Rutherglen Drainage District and then into the Glasgow Corporation Sewage Works, and, I have quoted, what the corporation insist upon the question is, would that silt up a sewer ? I think it is quite a point for investigation.

27567. It is very flocculent ?—Oh, it is. It might tend to silt up in a flat gradient sewer.

27568. Still that can be treated quite easily in the Glasgow Sewage Works ?—Oh, quite easily treated there.

27569. It is a mechanical objection ?—But with regard to the sewers themselves, the Glasgow Corporation, in their Acts of Parliament, provide certain conditions with regard to the admission of trade effluent. It is on p. 19, silting up, corrosion, or decay of the materials. Now, will that silt up a public sewer with a flat gradient ?

27570. That, of course applies to storage tanks at the works, so that it gets a preliminary settling beforehand ?—The question would be, must you ask the company to spend more money in putting down settling ponds or is that of itself sufficient to be admitted to the sewer ?

27571. That would be a question for the central board to determine, if it is constituted ?—Yes.

27572. Then I suppose we can dismiss also dyeing, bleaching, and finishing, in the same way ; it is at all events perfectly possible to obtain satisfactory results with the usual sewage treatment ?—Yes.

27573. Then the chemical works ?—We do not anticipate any trouble from these. And we have just the one distillery that has given us a good deal of concern in connection with admission to the Glasgow sewers.

27574. We have already investigated the possibility of disposing of distillery refuse, and that can be managed fairly well ?—Yes ; and also you have considered what preliminary treatment is required to admit it to a public sewer.

27575. (*Secretary.*) No, we have not.

27576. (*Chairman.*) That is the question we are really concerned with here. We will regard that as a question for the central authority, but there is no question that it can be treated.

27577. (*Secretary.*) Our investigation related to the treatment of it by itself to see if it was practical ?—Yes.

27578. (*Chairman.*) It is practicable to have a perfectly good effluent ?—That is our experience too.

27579. Then you merely allude to the question of standards. You say in connection with trade effluents, this important question has not given rise to any serious discussion. For coal-dross washing, 30 grains per gallon of suspended solids was mentioned some years ago. However, it can be treated ?—Well, but, Sir, I think there is an important point for consideration here. Reference has been made to water as raised from the mine. Now sometimes the water as raised from the mine is very objectionable, and, if they use that for coal-dross washing purposes, will not that control the standard. If you say you are not going to interfere with the water in the condition as raised from the mine, and you simply use that for washing, then there must be a big allowance made for the condition of the water for the washing as they get it. In connection with a mine there is generally what they call lodgments where they get pure water ; that is not the same as the water raised from the pit bottom, where a great deal of drainage has got into it. They try to catch it before it gets to the pit bottom in what they call lodgments and use that pure sparkling water for washing.

27580. That again appears to be under control provided the scope of the law is so enlarged as to comprehend mine drainage as well ?—Yes, Sir.

27581. Can you give us a notion of any particular works which it would be advisable to see ? Works presenting the most difficult problems or works which it would be worth while investigating ?—Yes, Sir. I have mentioned the Mossend Iron and Steel Works belonging to William Beardmore & Co.

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27582. Where are they ?—They are between Glasgow and Motherwell ; the railway station is Bellshill or Mossend, but it is no great distance from Glasgow. Then in connection with the paper mills and print works I think we have some places well worth seeing too.

27583. Also at Mossend ?—Mossend Iron and Steel Works. Within a mile of Holytown Station.

27584. This is a very valuable list of the methods adopted at present in ammonia works ?—Yes, Sir. I feel sure that there will be something interesting to be seen at some of these places ; there is such a variety of ways of dealing with it and I know that the companies would be only too glad to give the Commission every facility for visiting.

27585. Besides the Mossend Works ?—Oh, yes, Sir. The Carnbroe Iron Works, where they use it in the steam boilers ; then there is the Coltness, where they have a special evaporating plant. These could be all seen within a very short radius.

27586. You put down as a means of preventing pollution draining the noxious liquids into disused mines ; does that account for all the effluent absorbed ?—There is only one instance where we have reason to fear it coming into the stream. There is a natural drainage outlet from this disused mine ; it is away in a place called Wilsontown, and if you examined that drainage outfall from the mine you will get phenols to the extent of 7 or 8 grains per gallon. After having travelled for miles along these workings, at Wilsontown it comes out again into the stream.

27587. Then as regards any other works, is it worth while seeing any printing and dyeing, bleaching and chemical works ?—I think there it would, and the Clyde Paper Mills are quite convenient to the City of Glasgow. What is called the Glengowan Print Works and the Caldercruix and Moffat Paper Mills are all on the upper reaches of the Calder and quite near to each other, so that they could all be seen within a very short time. And it is rather a famous pollution ; it is one of the very first pollutions dealt with by an Inspector under the Act—Mr. Fletcher.

27588. As a general proposition, I suppose we may take it that the water, by the time it reaches Glasgow, is fairly pure on the whole and that the sewage of Glasgow tends to make the water more impure at present ?—Undoubtedly. Of course the county council are pressing all offenders, all sewage polluters, burghs and districts, county drainage districts, and we hope that within the next two or three years the amount of pollution will be very considerably reduced. Our present position is this, that practically all the serious pollution from public works has been dealt with satisfactorily for some years, but owing to the very very lengthy litigation that has taken place it is difficult to get the sanitary authorities all to fall into line. But when that has been done I feel sure that the city authorities will find that the purification, taking place on the upper reaches of the Clyde, is far greater than the amount of purification that is being carried out by the city authorities themselves.

27589. Then as regards standards, you think that some sort of standard ought to be laid down appropriate for each particular district or each particular work ?—I think, Sir, the answer is yes in both cases ; that is to say, you may have a public work discharging into a very large volume of water where the effect of the pollution would be small. But it is very desirable that there should be standards from another point of view. You might handicap an industry if you had one work being put to a very much higher standard of purification than another.

27590. That is so ; it would be an adjustable standard ; you might adjust it from time to time according to the exigencies of the case ?—Yes.

27591. (*Colonel Harding.*) I would just like to ask a question on the point of administration. I gather that both Mr. Munro and yourself thought that a Rivers Board, dealing with the whole watershed, would not offer any advantages over the present administrative arrangements ?—It would not.

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27592. But is it not possible that a local authority—let me say that of Motherwell—that is in your district, is it not ?—Yes.

27593. That is an important centre of population ?—Yes.

27594. Well, if their regulations were different to the regulations higher up the stream, might it not involve some hardship upon a manufacturer who is higher up the stream if he were called upon to do more than a similar manufacturer in Motherwell ?—Well, we have not had any experience of a difficulty of that kind for this reason, that to take the town of Motherwell, the order of court was only obtained say some two or three years ago, and they have only dealt with one section of the town yet; they have only put down one sewage purification work. Now until that town, and until every other town has put down a sewage purification scheme, then the question of standards or the amount of purification does not come in. If you had every town with a sewage purification scheme and we found that one town was doing very much worse than another then we would ask that town to do better.

27595. Then you have authority over that town ?—Yes, we have.

27596. You have the authority over that town which a Rivers Board would have ?—As a Rivers Board we have all these powers because they all must drain into our area.

27597. Then supposing Motherwell does not satisfactorily deal with its sewage have you some power of compelling them ?—All the power that any authority has under the existing legislation. That is to say, the Burgh of Motherwell's sewage outfalls discharge into county territory; they cannot do otherwise and therefore we are the parties to complain.

27598. You are the aggrieved parties ?—We are the aggrieved parties. Every town must drain into our territory. (*Mr. Munro.*) The real reason is that in Lanarkshire, as you see, Sir, now we have practically all the powers that a Rivers Board would have.

27599. You have now ?—(*Dr. Wilson.*) We have. (*Mr. Munro.*) We have. The only point I can see where a local authority such as you have instanced, Motherwell, might object would be that we have too great powers because if there was a Rivers Board they would have a voice, it may be a small voice, in dictating the policy to be laid down as regards the pollution of the River Clyde. As it happens, owing to our peculiar circumstances in Lanarkshire, we are practically the paramount authority and can lay down a standard of the highest efficacy, whereas if there was a Joint Rivers Board, Motherwell would be represented on it, and if they were aggravated polluters they naturally would do their best to reduce the standard.

27600. (*Secretary.*) But are they not now represented; have they not a member on the county council ?—No, not on the question of pollution. The town of Motherwell is represented on the county council, but for certain specified purposes, of which rivers pollution is not one.

27601. (*Mr. Stafford.*) Lanarkshire is the watershed of the Clyde really ?—Yes, the watershed of the Clyde; that is really the answer.

27602. (*Colonel Harding.*) Then your county authority has the power to lay down uniform regulations which would apply to all the burghs of the county, including this burgh ?—Perhaps I should have explained a little more fully the state of the law in counties in Scotland. I did not do so because Mr. Murray of the Local Government Board had given the explanantion; but that is ten years ago. In Scotland the county council is the overbody in regard to general matters of administration. Certain matters such as public health are administered by a subsidiary body which approximates somewhat to the rural district council in England and also the urban district council, what we call in Scotland a district committee. In Lanarkshire we have three district committees, who are the public health authorities. We also then have the burghs and the police burghs. The county council cannot themselves pollute because they have no works as regards drainage, but they are entitled under the Local Government Act as read along with the Rivers Pollution Act, to execute the Rivers Pollution Act, to be the authority which can enjoin the purification of the river, therefore they are entitled to call upon, not only the burghs which are separate bodies altogether from them, but also upon their own district committees, to purify, and that the county council of Lanarkshire, owing to the fact that it is the sole authority in the whole watershed, is now doing. In other counties in Scotland—take the Tweed for instance—where the Tweed drains through several counties there is a suggestion now that there should be a Joint Board, and quite properly so, because the interests of the several counties are bound up with the question of the River Tweed. That is the difference between the Tweed and the Clyde. The Clyde is wholly in Lanarkshire with the exception of that little bit in Glasgow; the River Tweed drains through a number of counties; therefore, while it is quite appropriate that the county council should be the authority in Lanarkshire, in other counties it would not be; it would be a joint authority, which the Secretary for Scotland has the power to appoint, and he is now about to do so with regard to the Tweed.

27603. With regard to the Cart, that, of course, flows into the Clyde, but is the authority over the purification of the Clyde the Clyde authorities ?—(*Dr. Wilson.*) Renfrewshire. There is one of the Carts which does come under us. The whole of the Cart is in Renfrewshire with the exception of the upper reaches, where there is no pollution to any extent, therefore if Renfrewshire were doing what we are now doing in Lanarkshire they could stop the pollution of the Cart by calling upon all the offenders.

27604. Of course, the sufferers are really the inhabitants on the banks of the Clyde very largely ?—The sufferers are really the town of Paisley. The Cart enters the Clyde where it is tidal.

27605. Still it is very dirty ?—It is very dirty. It is called the White Cart, but it is not; you will remember the old name for Lanarkshire was Clydesdale. The Valley of the Clyde. The boundaries have been laid down (pointing to map on wall) just to define the watershed of the Clyde.

27606. There is no authority except Renfrewshire that controls the Cart ?—(*Mr. Munro.*) No. Of course, Sir, the town of Paisley is quite entitled under the law to call for purification. (*Dr. Wilson.*) They are the biggest offenders.

27607. Have they taken any steps ?—(*Mr. Munro.*) On the general question I do not know of any local authority that has yet, with the exception of Glasgow and Lanarkshire, dealt with the whole problem in their respective areas. Now, I am glad to say, judging from inquiries which have reached me recently, more than one county council is taking the matter up seriously, not as a question affecting any individual pollution, but as affecting the whole county. Several of the important counties in Scotland are now taking the matter up. Fifeshire are doing a good deal, Midlothian is doing something, and I understand Stirling are going to take the question up seriously.

27608. Is there any authority to compel the Paisley Council or Renfrewshire Council to take up the question ?—The Secretary for Scotland can move in the matter.

27609. By his own initiative ?—He would have to get a complaint I have no doubt, but he could move under the Act. I have not looked up the point specifically, but I am quite sure that he could move.

27610. Has anything of the kind been done ?—The only case I have any knowledge of is in Aberdeenshire, where the particular pollution was that of a paper mill up there. Complaints apparently have reached the Secretary for Scotland that the local authority are not taking action to stop this pollution, and the Secretary of State for Scotland must have taken some action in the matter, because I have had submitted to me a memorial and opinion by eminent counsel, defining that the duty of the local authority was to take steps against the paper mill notwithstanding the fact that they themselves were offenders; so I think it must be. The only reservation in that opinion was this, that the Secretary for Scotland could not compel a local authority. Well, that is a different point. I need not mention that; but I am sure the Secretary of State for Scotland has the power on a compliant reaching him to order a local authority to take action under the Statute. I may mention, however, that I understand that in an English case an order was refused on the ground that the local authority were themselves polluting.

27611. (*Colonel Harding*). You have explained to us that the County of Lanark has, in the watershed of the Clyde, pretty much the same powers as the Rivers Boards have in certain parts of England ?—(*Dr. Wilson.*) Yes.

27612. But that is due to the fact that the whole watershed of the Clyde is within the County of Lanark ?—Precisely.

27613. But where watersheds extend into several counties you would agree that a watershed board would be advisable ?—Clearly.

27614. You have called our attention to certain effluents, among others to an effluent passing from lead mines. You have shown us a sample here which, when we first looked at it, was quite clear, but had a deposit at the bottom. You then shook up the bottle, and in the course of about half an hour I notice that this has become, not indeed as clear as it was before, but greatly clearer, and that we have now a considerable deposit at the bottom. Now what is there to prevent the authority of the county laying down a rule that an effluent from lead mines shall not be allowed to pass into the stream unless the suspended matter in it does not exceed a certain amount, say 3 parts per 100,000 or something of that kind ; is there anything to prevent you laying down a regulation of that kind ?—There is really nothing to prevent us, but if you were to go into a court of law, under the present Act of Parliament, you would require to prove that this was a noxious polluting liquid. Now would you be able to maintain in a court of law that that was so if they bring to you a sample with trout living in it ? That is the point. We have been dealing with what we looked upon as undoubted serious pollution. We have never lost a single case, thanks to the county clerk and the legal advisers, and we have been most anxious not to go into court upon any point that we really were not sure about.

27615. But you have power to prevent solid matter being deposited in the stream ?—No, Sir, not this.

27616. A person empties a cart-load of deposit of that kind into the stream ; you would stop him ?—No, excuse me, Sir, under the present Act of Parliament you cannot proceed under Part I., because under the definition clause it says that solid matter shall not include solids in suspension. You could take no proceedings under Part I.

27617. Then do you suggest to us that it would be advisable that the law should lay down a certain minimum of suspended matter in connection with that effluent ?—Yes, Sir, I think that this Commission should clear up this point. I may say when the County Council of Lanark took up the question of coal-dross washing, to begin with they were told by some neighbouring authorities that that is not a pollution. They thought the wording of the Act was so peculiar. You see it is very largely solid matter. You cannot take action under Part I., although we could take you to streams where the bank and sides were simply silted up with this solid material, because of the definition clause applicable to Part I. Then under Part III. it could be shown that it was not injurious to fish life ; was it really noxious ? Now thanks to the way the cases have been put we have been successful and the County of Lanark is, I think, the first and only county that has been successful in taking a case against offenders for polluting by coal-dross washing. We, therefore, suggest to you that all doubt should be set aside as to what really is a noxious polluting liquid. I think these are all eminently matters for investigation.

27618. And you suggest to us that it might properly be laid down in new legislation that suspended matter was noxious ?—I do think so.

27619. Beyond a certain minimum ?—Yes, without doing any injustice to the manufacturing industry, a great deal of improvement could be made.

27620. And quite evidently, in a case like this, by the provision of inexpensive settling tanks, all this might be withdrawn from the river ?—Yes, Sir.

27621. Then you spoke to us about the residual effluent from gas liquors. I suppose the general character of it is the same, whether it comes from a gas plant or from a coke plant or from blast furnaces, or from Mond gas production and so on ; the general characteristics are the same ?—Yes, Sir, it is so.

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27622. And they are all equally, or nearly equally objectionable ?—From the point of view of rivers pollution they are all the same ; that is to say, they all contain phenols in great quantity or allied bodies that are of a poisonous and noxious character.

27623. Would you consider that that class of effluent was the most important in your district to be dealt with ? —I would so consider it.

27624. And you would suggest to this Commission that it is an important thing for us to study to see if some means could be devised for purifying this residual gas liquor ?—Yes, Sir, I do suggest that.

27625. Then apart from gas liquor, which would you consider the next most important matter to be dealt with in your district ?—The colour discharges.

27626. Now what has been found to be the effect of these colour discharges ; do they affect the life of the fish ?—I do not think so.

27627. Do they interfere with the use of the water, say as drinking water for cattle ?—I believe not to a great extent. The streams that are mainly affected have been so much affected otherwise that I do not think cattle have much access to them, but it is more just the appearance that is so objectionable. It gives the stream a blood-red colour ; it altogether alters the character of a natural stream.

27628. And one could imagine that it depreciates property ?—Undoubtedly. Certainly you cannot use it for primary purposes, washing clothes, it would stain your handkerchiefs, or you could not use it for domestic purposes at all.

27629. Now what experiments, if any, have been carried out in your district for the purpose of removing this discolouration ?—Well, first of all they have tried to sort out the different liquids produced, say, at a printing work, that is to say take the colours by themselves and submit them to sulphate of alumina and iron. I think it was ferro-sulphate they tried first and then sulphate of alumina. And what they do find is that it involves a pretty heavy expenditure, the amount of liquid produced is very considerable and they are very apt to neglect unless you have inspectors on the spot.

27630. Then have you not in Scotland legal enactments that enable you to call upon the manufacturers to take every reasonable and practicable means known to prevent this discolouration ?—Yes, Sir, but the answer here again is just as before, would we be successful in that court of law in saying that was a noxious polluting liquid ? That is the difficulty, you have got to prove this to be a noxious polluting liquid before we would succeed.

27631. What you want is that the law should state clearly what is noxious ?—Exactly.

27632. And should state, probably, that some other word should be introduced instead of noxious ?—Yes, Sir.

27633. So that it might be proved that this was an injury say to property owners even if it were not an injury to health ?—Exactly. And it is a question how far the suggestions already made about the central board and the administration would effect the end we have in view. If such questions could be referred to the central board I think it would be alright.

27634. Then your county council, as such, has not carried out any laboratory experiments or other for the purpose of endeavouring to solve this difficulty ?—We have not, Sir.

27635. (*Chairman.*) Nor the manufacturers in your district ?—Well, the manufacturers came to England to see what was done there and learn of them. I know both paper mills and bleach works and print works have done that, but I was led to believe that in many parts of England they got no help ; there were offenders there just as they were.

27636. (*Mr. Tatton.*) Is it possible to treat that colouring matter ; do you know any means of removing it at all ?—Well, sulphate of alumina, either with or without lime, does take out the colour pretty efficiently, but it requires to be carried out in a really scientific way, the

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amount of alumina and the point at which it is introduced, the area of the settling ponds afterwards. As I said this is the effluent—(*Exhibiting sample in bottle.*)—the colour of the effluent that was got that day that these samples were taken.

27637. Was that there, that red dye, the same red dye ?—Those colours all mix together along with the bleach house liquor. This shows you the effect of the sulphate of alumina—(*Exhibiting sample in bottle.*) This causes a reddish precipitate to come down—(*Exhibiting sample in bottle.*)—and this is after it has gone through the pond—(*Exhibiting sample in bottle.*)

27638. (*Colonel Harding.*) So that their settlement is of some use ?—Undoubtedly. Oh, their plant is fairly good. We have never got any decision in a court of law that would enforce that. I should say that we have been helped here by riparian proprietors. (*Mr. Munro*). The point that Dr. Wilson and I both make is that even to get that apparently very much improved effluent it is very doubtful if we could enforce that. (*Dr. Wilson*). That is it. (*Mr. Munro*). Because we could not prove that the first highly coloured thing was a pollution in view of the fact that discoloured matter is said *per se* not to be.

27639. Then what grounds have the riparian proprietors to go on ?—Well, the riparian proprietors are in a very much stronger position as regards pollution than the local authorities, because they can deal with the primary use of the stream. If the riparian proprietors would only combine the matter would be dealt with very soon, because they are in a very much stronger position than the local authority. (*Dr. Wilson*). In that connection I would like to add, if the Commission suggest there should be no litigation, it would be a wonderful change ; that is to say, there have been case after case taken into court by riparian proprietors and by farmers, alleging that their streams were polluted and cattle were dying. It is rather a favourite way now of getting money out of people for the farmers to raise actions. It would make a great change in Scotland in our area if the Commission's recommendation were given effect to, that there is to be no litigation now at common law.

27640. (*Mr. Tatton*). Would your suggestion of standards go beyond the question of suspended matter and of discolouration ? If you had standards, if standards were adopted, would you suggest other standards ?—I do not know of anything else so far as our particular district is concerned.

27641. These are the most important, suspended matter and discolouration ?—Yes, these are the most important.

27642. (*Chairman.*) You are dealing with trade effluent ?—Trade effluent.

27643. (*Mr. Tatton.*) Would you have one standard for the whole of your district ?—I think not. Each particular industry or trade effluent would require to be dealt with by itself I think. As regards suspended matter, I think whatever you laid down, either for coal-dross washings or lead washings, would control everything else ; you have the greatest amount of suspended matter there. (*Mr. Munro*). This is rather important. Of course you mean the question, would you have one standard for the whole river or different standards for different reaches of the river ; is that the question ?

27644. That is so ?—The question is, would you propose that there should be different standards for different reaches of the river ?

27645. I will put it in this way, would you have one universal standard over the whole of your district as regards suspended matter ?—Yes ; there would be no difficulty with regard to that.

27646. I quite see as regards others ?—Colouring and poisonous, each would stand upon its merits.

27647. Would you be able to bring all the works in your district up to one standard ?—(*Dr. Wilson.*) I feel quite sure of that. Coal-dross washings and lead mine washings are the only things that you have to consider, and they could quite well do it.

27648. Is it chiefly rural ; I mean are they large works, and would they have plenty of room to put down efficient settling tanks under all conditions ?—There are very large works all over, coal-mining works especially being developed into large concerns now, and they have provided very large settling tanks in connection with their coal washers. And then you know they have always plenty of steam there. They can raise the water on to what you would call a waste refuse heap, and there they can construct ponds 20, or 30, or 40 feet up from the ground and they would have no difficulty whatever in dealing with it.

27649. You have no instances of works that are restricted in their area where there would be very little room for them to put down efficient settling tanks ; you have got none of that kind ?—We have got none of that kind, Sir, no.

27650. (*Mr. Stafford.*) As to removing the colouring matter, have you tried any other methods excepting the one you have mentioned ?—No other method.

27651. You have never tried filters ?—No. When they take out the colour with the pulp at a paper mill they press it to get out the liquid, of course, but we have never tried the effect of that on the colour alone, dissolved, no ; and I think in Scotland generally I could say that some precipitant is the only thing that we know of having been applied to colour.

27652. With regard to the standards do you think there ought to be different standards on different reaches of the river ; did I understand you to say that ?—Oh no, Sir ; I think one would put it in this way ; as regards suspended matter you can quite well have one standard for the whole river. There should be no difficulty in producing a liquor ; say that either 20, 30 or 10 grains of suspended matter is right to be fixed upon, but with regard to colour and with regard to poisonous materials that must vary with the particular trade effluent.

27653. But you would not approve of having different standards on different reaches ?—That would be quite unnecessary as far as our experience goes. No, we would not approve. I am going upon our own experience.

27654. (*Mr. Tatton.*) If you made your standard much more severe ; supposing instead of saying 20, 30 or 10 grains in suspension you said 2 or 3, would that increase your difficulties ; would you be able to get works sufficiently large to get a standard of that character ?—Two or three ; there would be difficulty, I think, oh, yes.

27655. If you got above that would you not expect to have your rivers very highly polluted ?—Oh, no, Sir ; 10 grains of suspended solids, or 10 parts per 100,000, would not be at all a nasty liquor.

27656. Have you any woollen works in your district ?—No, Sir.

27657. Print works, calico print works ?—The suspended solids I have in my mind are mineral solids.

27658. Have you calico print works ?—Well, with them, perhaps, 10 grains would look rather nasty, because it is light and fluffy ; it is not like the mineral. I think, perhaps, to meet a case of that kind you would make a distinction whether the suspended material was mineral or vegetable.

27659. Bleach works ?—Yes, Sir. Ten grains say of sandy material would not look objectionable, because the bulk in relation to weight is small ; but if you were dealing with 10 grains of suspended material from paper mills, or from woollen works, it might be otherwise.

27660. Well, take the effluent from that calico print works ; if that had passed through settling tanks this heavy matter you have spoken of would remain in the settling tank, and if you had still 10 grains left after passing through the settling tanks would not that cause serious pollution in a stream ?—Yes, it might be objectionable ; it might be, but I do not think there is need for investigation on that point, if I might put it that way. We ourselves have done no research work, but from our experience there would be no difficulty in dealing with suspended material, and I think there would be no difficulty in having one standard for the whole of the River Clyde, but vary it according to the particular industry. If it is a mineral suspended material, then one standard for that, and if it is vegetable fibre, another standard for that.

27661. (*Mr. Stafford.*) That only refers to trade waste, does it not ? You are not dealing with sewage ?—Yes, not dealing with sewage.

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27662. (*Chairman.*) Do you find that the manufacturers co-operate with you ?—They do, Sir.

27663. Are there any who oppose you strongly who would state the other side, because we want to hear both sides ?—(*Mr. Munro.*) You might, Sir, get evidence from representatives of certain of the trades whom we had to take into court ; they might be able to tell you that we were oppressive. It is perfectly fair to hear the other side. They might tell you what our action cost them in money. The Carnbroe Company or the Clyde Iron Works, James Dunlop & Co., Ltd. With both of them we had expensive litigations but they ended up very pleasantly. Either of these companies might be able to say that we were oppressive. I do not think they would, but they might. (*Dr. Wilson.*) This is spent liquor, Sir.—(*Exhibiting sample in bottle.*)—(*Mr. Munro.*) On the question of the coal, whether we had been too drastic as regards coal-dross washing, you might communicate with the Coal Masters' Association, and on the other question you might also communicate with the Iron and Steel Masters' Association. I will be very glad to give Mr. Willis the names of the Secretaries.

27664. They can choose their own witnesses ?—Yes. Then as regards the paper makers, I will think the matter over and see.

27665. (*Colonel Harding.*) Just one more question ; has distillery refuse played an important part in your works ?—(*Dr. Wilson.*) We have only two distilleries. One is situate in a burgh and drains to a sewage purification scheme, land irrigation ; there has been no trouble there as far as I know.

27666. You have no important distilleries ?—No, Sir, none running direct to the stream. (*Mr. Munro.*) On the general question, as regards rivers pollution in Scotland generally, I would like just to refer to one matter in my notes, that in Scotland as a rule, unless there is special legislation, local authorities must repay money borrowed for the purpose of sewage purification works within thirty years. Now I understand that is shorter than in England. Certain local authorities in Scotland have got special privileges. The City of Glasgow gets sixty years to repay in, and my own county, by promoting a private Act of Parliament, and obtaining consent to it, have got fifty years to repay in. I mention the fact because what has been given to us by special legislation it seems only reasonable that other local authorities should get, because I know for a fact that the expense of putting down purification works is a very considerable deterrent in the minds of local authorities in executing works. If they got longer time to repay the cost falling upon the ratepayers would be less, and I think there would be very much more readiness to put down purification works. I do not know if it is outside the scope of the Commission, but it is a matter that might be referred to, seeing the law of England gives fifty or sixty years, and seeing that the local authorities of Glasgow and Lanarkshire have got special time.

27667. (*Secretary.*) In England, under the Public Health Act, the Local Government Board have power to fix the term of each loan when they sanction that loan, and up to a maximum of sixty years ; they may not go beyond that ; but they practically never allow more than thirty years for works of sewerage ?—Nor for purification works ?

27668. Nor for purification works, nor have they any special times ?—To that extent my analogy with England fails. But there is no authority in Scotland except these special local authorities that I have mentioned that get sixty years.

27669. A special local authority may get anything ; Parliament has given 100 years for a thing that has perhaps not lived for more than ten years ?—Might I put the point, the question as to whether a relaxation of the period for repayment of loans might not be an appropriate matter for the Commission to consider.

27670. (*Chairman.*) It is quite relevant ?—I do make the point. And one other point ; I find I was right in saying that the Secretary for Scotland has the power in Scotland, as the Local Government Board has in England, to compel a local sanitary authority to enforce the provisions of the Rivers Pollution Act if complaint is made.

27671. (*Mr. Stafford.*) You agree some regard would be had for the probable life of the works ?—I agree. I had to satisfy the Secretary for Scotland that fifty years was the workable period. In Scotland we are not under the control of the Local Government Board as regards the period ; we are entitled to borrow up to thirty years for the special periods where allowed.

27672. (*Secretary.*) Without any sanction at all ?—Without any sanction at all unless we go to the Public Works Loan Commissioners.

27673. You have not the advantage of the advice of the inspectors then ?—No ; the county authorities borrow the money. We have no inquiries as you have in England.

EIGHTY-EIGHTH DAY.

Wednesday, 27th January, 1909.

PRESENT

Mr. R. A. Tatton, M.Inst.C.E. (*in the Chair*).
Colonel T. W. Harding, J.P., D.L.
Sir William Ramsay, K.C.B., F.R.S.
Mr. T. J. Stafford, C.B., F.R.C.S.I.
Mr. F. J. Willis (*Secretary*).

ALSO PRESENT

Dr. A. C. Houston.
Dr. George McGowan.
Mr. G. B. Kershaw.
Mr. C. C. Frye.

Mr. Edward Halliwell, F.I.C., Chief Inspector to the Ribble Watershed Joint Committee, Preston, recalled ; and Further Examined.

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27674. (*Chairman.*) I think you are a Fellow of the Institute of Chemistry ?—I am.

27675. And Chief Inspector to the Ribble Watershed Joint Committee, Preston ?—I am.

27676. You have given evidence before the Commission ?—Yes, I gave evidence three years ago on questions of standards, storm waters, and mill dam sludging.

27677. This statement which you have been kind enough to send in to the Commission it is proposed to print *in extenso*; therefore, what we propose to do is to ask you questions on that or, if there is anything that you would rather amplify, of course, we shall be most happy if you will do so ?

(*The Witness handed in the following Statement.*)

The following are the trades in the Ribble Watershed in which large volumes of water are used for the various processes (other than for steam raising or condensing) and which have finally to be dealt with under the term of waste water :—

(1) Paper trade.
(2) Calico bleaching, printing, and dyeing.
(3) Brewing.

It is necessary to point out that it has been the policy in this watershed to obtain as far as possible the treatment of liquids from breweries, tanneries, and chemical works at the sewage works of the various local authorities. With the exception of two small breweries and one glue works they are all connected to the sewers.

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(1) PAPER TRADE.

Under the one head of Paper Trade are included all the trades in which the manufacture of paper is the essential feature. There are many different kinds of paper, and as each class of paper is made from different raw materials the resulting trade liquids are practically as different as if each branch were a separate and distinct trade.

(a) WHITE PAPER.

This must again be sub-divided into :—

(1) News paper.
(2) Wall paper.
(3) High-class news and printings.
(4) Note paper.

The manufacture of paper may be roughly divided into three stages—firstly, the preparation of the raw materials ; secondly, the actual process of making the paper ; and, thirdly, the dyeing, printing or staining of the prepared paper. In each of the processes, which are separate and distinct, large volumes of water may be used, and grossly polluting liquids result therefrom.

(1) *News Paper.*

Raw materials.—Wood pulp, china clay, salts of alumina, and dyes.

Wood pulp is of two forms, mechanical pulp and chemical pulp. Mechanical pulp requires to be bleached, chlorine being the agent usually used, whilst chemical pulp is practically ready for use.

In this class of paper the preparation of the raw materials does not require a great deal of water, and the waste liquids have suspended matter as their main form of impurity, together with a small amount of chlorine and dilute acid. Such liquids are passed direct to the purification plant.

In the second process—the actual making of the paper —very large quantities of water are used. The water discharges direct from the paper machine, and contains the fibre, china clay and alumina salts which have not been retained on the machine wire. This water, called machine or back-water, is common to all the paper trades. It is usually pumped into tanks situate in the mill, and called back-water tanks. They are of various forms and are used with the object of allowing the grosser suspended matter to settle out, the deposit is drawn off at frequent intervals and mixed with fresh raw materials. A part of the supernatant water is used in the preliminary processes. Recent improvements have been made, and in place of or in addition to tanks, the liquids are passed through a filter consisting of a travelling blanket so arranged that waters are passed by their own head through the material of the blanket, leaving a thin layer of fibrous material, which is automatically scraped off. Whatever the forms of the preliminary processes the resultant liquids are by no means satisfactory and require further treatment.

The treatment in this watershed consists of settlement in tanks, used either on the continuous or intermittent flow system. The results generally are highly satisfactory, depending on the available tank capacity. The amount of sludge deposited is very large, and in the majority of cases sludge presses have had to be installed. The tanks require very frequent cleansing. The suspended matter can be reduced to two or three parts per 100,000, and the dissolved impurities are also small owing to the clean nature of the raw materials used. Where a coloured paper is produced the effluents contain a small amount of colouring matter.

Up to a few years ago the recovered sludge was discarded as being of no value. It has been found that there is no great difficulty in re-using it, and I am personally acquainted with one works where a minimum profit of £1,000 per annum, after payment of expenses, is regularly obtained. The sludge from the mill at one time was habitually surreptitiously discharged to the river.

See Analytical Tables—Works A., B. and C. for results of treatment.

(2) *Wall Paper.*

(3) *High-Class Notes and Printings.*

Raw materials, fibrous matter.—Wood pulp, esparto grass, clean rags.

Bleaching materials.—Chlorine and acids.

Loading agents.—China clay, pearl white, resin, etc.

Dyes and printing materials.—Starches, resins, dyes, mordants, lakes, etc.

In the preparation of the materials a great volume of water is used, and very polluting liquids—difficult of treatment—are produced. Substances other than wood pulp, such as esparto grass, have to be boiled under pressure in kiers with a strong solution of caustic sodas. This treatment dissolves the resinous, glutinous material of the grass and some of the cellulose. In fact, half of the weight of the grass is removed. The kier liquor is run off and the grass washed several times with hot water. The kier liquors and first washings are very strongly alkaline and rich in organic matter. They are evaporated under reduced pressure and finally burned with a view to the recovery of the alkali. The ash, after burning, is dissolved and causticised, and the recovered caustic soda re-used. This part of the process is carried out at a profit. The third and subsequent washings of the grass are considered too dilute to pay for evaporation. These liquids still contain a considerable quantity of alkali and much organic matter, and are extremely difficult to treat in the purification plant. The washed grass has now to be bleached and washed, the different waters all requiring treatment.

After the materials have been prepared there is the actual process of paper-making, in which a large quantity of water is used. The machine water is treated in back-water tanks and finally goes to the purification plant.

In the case of wall papers, which have to undergo printing and dyeing, the printing rollers, colour boxes, dye becks, etc., have to be washed and the wash waters sent to the purification plant. Some of these waters are difficult of treatment on account of the thickening agents used in preparing the colouring materials and on account of the dyes.

The method adopted for purification of the mixed crude liquids consists of settlement in large tanks, generally with the addition of precipitants. In some cases filters have been put down. The amount of sludge settled out is very great, and presses are usually required. The pressed sludge appears to have no value, probably owing to the admixture of sludge derived from the waters in the preparing processes. The results generally are unsatisfactory, the suspended matter varying considerably. It is of a fine nature and is not even retained on the filters. The difficulty of treatment appears to be almost entirely due to the wash waters which in some cases are very strong, and require a large amount of precipitant. At one works the results have markedly improved owing to the addition of vitriol to the wash waters as they are run from the kiers. The volume of waste water is very large, amounting in several cases to 750,000 gallons per day.

See Analytical Tables—Works J, K, and L.

(b) BROWN PAPERS.

All sorts of brown paper are made in this district, from the heavy browns to the groceries and thin browns.

Raw materials.—Wood pulp, rags, bagging, waste paper, old tarpaulin, peat, etc.

Bleaching agents.—Lime, chlorine, acids.

Loading agents.—Colouring matters, sulphate of alumina, china clay, resin, etc.

The first part of the process consists in boiling the fibrous materials with lime to remove dirt and grease. The kier liquors and wash waters are very grossly polluting and difficult of treatment. The kier liquors from the lime boil, unlike the soda boil from the esparto liquors in the case of white papers, give no product worth recovering. The machine waters are pumped to back-water tanks and the overflow sent to the purification plant.

The usual mode of treatment is by settlement with or without precipitants, and, in some cases, filtration. The results are not satisfactory. It is possible to more or less thoroughly remove the suspended matter, but the resultant liquids are highly charged with organic matters which, in some cases, rapidly putrefy. Sludge presses are often needed to deal with the large amount of sludge.

In my opinion, at some mills, it is possible by means of efficient settling tanks to obtain liquids which might be discharged to any river, but the effluents from mills using esparto and fairly clean rags contain organic matter and suspended matter of a fine character, or as colloidal matter, and do not easily give satisfactory

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results The organic matter does not seem to be in a putrid state, possibly owing to its clean nature, to the heat used in the preliminary processes, or to the large amount of chemicals used. In the brown mills, settlement removes a very large amount of suspended matter, but the filthy character of some of the raw materials, together with the lime, makes it difficult even to remove the suspended matter. In some cases the liquids on further cooling deposit more suspended matter. The organic matter is also very putrid, and would possibly require several contacts or very deep filters to effect an efficient purification. It is possible that, if the worst of the waste waters derived from the preliminary processes of cleaning the fibrous materials could be discharged to the sewers, the machine and other waters might be more easily dealt with. The volumes from the various paper works are very large and vary from 100,000 to 1,000,000 gallons per day. The effluents are generally hot. It must be borne in mind that paper works are in continuous operation from Monday morning to Saturday, so that crude liquids are discharged to the purification plant during twenty-four hours every day.

See Analytical Tables for results of treatment—Works D, E, F, G, H, and I.

(2) CALICO BLEACHING, PRINTING, AND DYEING.

The processes in bleaching consist briefly in treating the woven material, firstly, with alkali (either lime or soda) and washing; secondly, with acids and washing; thirdly, bleaching with chlorine from bleaching powder, acidifying and washing, and, finally, soaping, starching and filling. The number of times these processes are repeated depends upon the class of goods treated and the finish required.

In the case of the kier liquors, in which either lime or soda is used, the resultant waste liquids are most difficult of treatment. They are strongly alkaline, and contain in addition a large amount of starch, fatty and waxy matters, and are discharged at a high temperature. The wash waters are of the same form but very much more dilute. The liquid from each bleach works seems to be different and depends on the class of goods. The volumes are very large. The treatment usually adopted is settlement with or without precipitants, and, in many cases, filtration. Some of the results are more satisfactory than others. In some cases deposition of suspended matter appears to be slow, and in others the suspended matter is so finely divided that the filters do not remove it unless they are practically choked. At times the effluents are distinctly putrid. This putridity seems to depend upon the amount of sludge in the tanks and the temperature of the liquids and the air. Coarse filters do not remove the starchy matters. The kier liquors ought to be treated separately. It is possible that the other waters would lend themselves to treatment by settlement and filtration.

At one works very complete filters have been installed. These works have been seen by your Mr. Frye, who has details of their construction. Putrid fermentation is encouraged by turning sewage into the settling tanks. The results show distinct purification of the dissolved impurities, but only the wash waters are treated and the lodge into which the effluent is passed shows distinct signs of fungus. The kier liquors are treated with the dye waters in a separate set of tanks.

At another works sewage sludge was added to the tanks with a view to setting up a putrid fermentation and finally treating the liquids on a continuous filter. In this case the results were not satisfactory The uncertain rate at which the crude liquids were discharged to the tanks, the chemicals present, and the peculiar character of these, in that they contained a large amount of china clay, caused the effluents to be very unsatisfactory. The filter quickly became choked, and a large volume of the tank effluent passed over the surface of the filter instead of through it.

In some cases sludge presses have been found to be necessary. In one case the pressed cake is easily burned, and the resultant ash is used as a manure.

By some firms bleaching alone is carried out. In the cases of some of the large print works they do their own bleaching. The trade is so mixed that it is impossible to divide them into separate groups.

In calico printing each firm has a different class of liquids to deal with, and there is no finality in a firm's class of work. With one firm the liquids are generally blues and blacks, with another firm it will be reds, and a third firm a mixed trade; in fact, each firm often has a speciality of their own, and a general trade.

The crude liquids contain starches—ordinary starch and soluble starch—gums, soaps, dyes of all colours, mordants—such as the salts of tin, zinc, aluminium, chromium, etc.—dungs, resin, china clay, and other minerals. In some works a practice is made of scraping out the solid matter from colour boxes, mixing tubs, etc., and removing it in a solid form. In other cases it is washed out and sent to the purification works. The removal in a solid form of the starches, gums, and lakes is very desirable. The dyes are of all colours and compositions, including the sulphur dyes. It will, therefore, be readily understood that the waste waters may contain anything and everything, and are very difficult to deal with. In some works a process known as mercerising necessitates the usage of a large amount of caustic soda, and the liquids are strongly alkaline.

The alkaline nature of the crude liquids in some cases makes it more difficult to treat. One or two firms make their own soda from sodium carbonate by adding lime. The huge amount of calcium carbonate so formed is in some cases separately removed. In one case it is sent to the purification tanks, and although acting as a precipitant, it adds very considerably to the sludge difficulty.

Treatment in tanks, with or without the addition of precipitants, removes a large amount of suspended matter in the form of sludge. The effluents still contain suspended matter. In some cases they are highly coloured, in some they are distinctly putrefactive, and others give rise to slimy growths in the beds of streams. Filters are used at many works, but the area is limited and the volume treated per cubic yard is such as to prevent any extensive bacterial purification even if such is at all possible. When a filter is first used it appears to remove a small amount of colouring matter.

Sludge lagoons may give rise to local nuisance, and in the cases of one or two works where the settling tanks are practically old reservoirs and difficult to clean, gases are freely evolved and putrescence seems to be set up.

Several works where indigo is used have a separate plant for the treatment of the indigo waste waters. The indigo sludge is re-used.

(3) BREWING.

In this watershed all the breweries, with the exception of two, are connected to the sewers. These two breweries are very small and the volume of liquid to be treated amounts only to a few thousand gallons. In one case where alterations are being carried out there seems no doubt that satisfactory results will be obtained if a sufficient depth of filtering material is available.

GENERAL.

The pollution of the tributary streams of the Ribble by trade waste is due not so much to the number of factories turning out trade liquids as to the large volume discharged from each works. In several cases the volume from bleach works and print works amounts to several million gallons per day. The fresh water lodges of the firms are many acres in extent, and are as large as the reservoirs of many of the towns. The rivers in dry weather consist very largely of the effluents of the various purification plants and sewage works, and in addition the waters of the streams are used by a number of cotton mills for the supply of boilers and condensers, and becomes distinctly hot.

Manufacturers, as a whole, have been desirous of removing the suspended matter from their trade liquids, but the necessity of pumping, the provision of sufficient settling space, the difficulty of running off top water without running off sludge, the difficulty of sludge removal, can be overcome only at considerable expense. The removal of dissolved impurities such as starch, gummy matters, organic matters derived from fabrics and from the dungs and other materials used, are still pressing problems.

In July, 1898, the Ribble Joint Committee took proceedings against Messrs. Potter & Co., Paper Makers, Almonds Mill, Darwen, for the pollution of the River Darwen by the liquids resulting from the manufacture of brown paper. Settling tanks had been constructed and a filter press installed, but the final effluents contained suspended matter and were unsatisfactory. It was

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admitted by the defence that the effluent from the mill was of a polluting character, but it was claimed that owing to local circumstances the cost of constructing an additional tank was prohibitive, and that they had used all reasonable means with due regard to cost and the effect on the trade. The case was tried in the High Court of Justice, Queen's Bench Division, before Mr. Justice Bruce and a special jury, when the case was dismissed, it being held that they had adopted reasonable means for rendering harmless the polluting liquid.

D.—WHETHER THE CONDITION OF THE RIVERS IN THE RIBBLE WATERSHED IS IMPROVING.

We have no reliable figures to show the change in the rivers in the Ribble Watershed. During the last twelve months samples of the River Ribble before its junction with the River Darwen, the River Darwen, and the Ribble after its junction with the Darwen have been taken monthly, and a table of the analyses is handed in (*see* tables at end of Mr. Halliwell's evidence).

Samples of other rivers have been taken, but no regular routine has been observed.

Although there are no analyses to prove it, I have no hesitation in saying that the rivers show a marked improvement, and this opinion is borne out by a number of independent statements made to me from time to time by people who are in touch with the rivers or are users thereof. The Ribble, which is a noted salmon stream, has, particularly during the last two years, contained a large increase of salmon and sea trout. I have been so informed by a number of fishermen, who state that although the fishing has been poor the number of fish in the stream has been wonderfully large. The bad fishing has been due to natural conditions and not to pollution.

It is extremely difficult to prove that a river is improving owing to many factors, such as rainfall, rate of rainfall, period of drought, temperature, condition of trade, local holidays—which have a marked effect on a stream—and numerous other considerations.

The beds of the streams also show marked improvement. The River Calder, whose main source of pollution is sewage, shows probably a greater rate of improvement than either the Douglas or the Darwen, both of which streams contain a very much larger proportion of manufacturers' trade liquids.

The tributary streams of the Ribble are by no means satisfactory, but any temporary dislocation of purification plant by a breakdown of pumps or from other causes increases the pollution and has a marked effect on the stream.

Standards for Trade Effluents.

I should very much like to see standards fixed. I think that a standard for the amount of suspended matter could be fixed, and would be of advantage to manufacturers and administrative bodies, but other forms of pollution by dissolved impurities would remain to be dealt with, and for these forms a standard would be much more difficult. Soluble impurities take many forms. In some trades, such as breweries, tanneries, paper works—particularly brown papers—bleach works, dye and print works—particularly where dungs are used—and other trades, the organic matter still in solution is putrescible and actually putresces. Other liquids contain a large amount of dissolved organic matter which, although not giving actual putrescence in the incubator, may give objectionable odours and even putresce on passing through lengths of river where the flow is very sluggish and where much sludge has accumulated, due to many causes, particularly storm overflows and road waters. Other dissolved impurities, such as soluble dyes and metallic poisons, will increase the difficulty of fixing a standard.

One of the main advantages of a standard would be that the clause in the Pollution Act dealing with the availability of means with due regard to cost, etc., would have to disappear, as that section would be contradictory to a standard. If a manufacturer found the cost of constructing a plant, capable of so dealing with his liquids as to come within the standard, prohibitive, he could be given the power to appeal to the Rivers Boards or Central Authority to have the standard in his case adjusted to meet his difficulties. It is very essential in considering the possibility of fixing standards for trade waste to have ever present in one's mind the possibility that, although the manufacturer by reason of the volume or nature of his trade liquids may have to construct or enlarge his own purification plant, yet possibly a portion of his liquids, particularly that portion which is most polluting and most difficult to deal with and probably only a small portion of the whole, could be discharged to the sewers.

I have not had sufficient experience of the standard suggested by the Commission and based on the rate of absorption of oxygen to give any opinion as to whether this standard is likely to be workable for trade liquids. I am making tests on the lines of the standard and should be glad, if the Commission should think it desirable, to give the results of such tests and my opinion thereon after the lapse of a few months. I should like to add that as far as the tests have been made there is a strong probability that some trade effluents which do not absorb oxygen when tested alone do so when mixed with a satisfactory sewage effluent.

There are degrees of pollution by trade liquids which it is highly probable that a Rivers Board or Central Authority would not consider as being objectionable, but which might be a source of injury to certain persons or industries where they require their water supply to be free from all forms of pollution, particularly of slight colours. Such riparian rights should still be, in my opinion, respected, and damages recoverable by interested parties.

Investigations Required and How to be Carried on.

I believe it is practicable for manufacturers to remove suspended matter and some soluble matters such as soap by settlement with or without the addition of precipitants. In many cases manufacturers have provided filters, but I think it very desirable, even essential, that experiments should be made on a large scale to see whether the filters have any purifying effect over and above a simple straining effect. In this watershed there are many purification plants which include filters. Such filters, with one or two exceptions, appear to do little more than act as strainers. The coarse material of the filters, the lack of satisfactory means of distribution, the large volume treated per square or cubic yard, make it difficult to prove that filters have or can have any other effect. In suggesting the investigations to be carried out one has to bear in mind that at the works where a form of treatment over and above the provision of settling tanks is required the volume will be very large or the liquids very strong, as otherwise such liquids could be treated at the sewage works.

I have little doubt that brewery and tannery wastes are amenable to treatment either in contact beds or continuous filters if sufficient area and fall are available, and cost is not limited.

We have in this watershed several works with a volume from each works varying from 500,000 to 2,000,000 gallons per day, and such liquids at times, particularly in summer when the river consists of practically nothing but trade effluent and the temperature is high, show distinct signs of putrescence on incubation, and also give rise to growths in the bed of the stream.

Investigations are urgently needed to prove that the liquids from dye works and bleach works which contain starches, gums, resins, and other organic matters derived from dungs (as also waters after the removal of grease from wool and piece scouring) can be purified by biological filters; what area and depth of filter is necessary and also whether a preliminary treatment to set up putrefactive fermentation is necessary. The nature of these liquids is so variable that what is successful in one case may not be in another, and therefore many experiments at various works will possibly be necessary.

Manufacturers in the watershed have, in many instances, been prepared to go to considerable expense to treat their liquids, and have shown a desire to prevent pollution and I believe they would give the Commission every facility for putting down experimental plants, and it is possible, although doubtful, that some of the large combinations would make financial contribution.

There is at Leyland, at the works of Messrs. Stanning & Sons, Ltd., Branch of the Bleachers' Association, a very complete set of tanks and percolating filters. One set of tanks and the filters is intended to deal with the dilute wash waters from the bleaching processes. Putrefactive fermentation is set up in the tanks by allowing the sewage from the factory to discharge thereto. The

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object of the firm, in addition to preventing the pollution of the stream, is to re-use this water, as their supply is somewhat limited. Samples of the different crude liquids have several times been taken, and the analyses thereof are enclosed. It might be possible for the Commission to arrange with the Association for experiments to be carried out at these works.

Another series of experiments which, in my opinion, are advisable, is with respect to the effect of the non-removal of sludge from tanks and the possibility of such sludge becoming liquefied and being removed in a soluble and putrid form in the final effluent.

E.—WHETHER THE LAW SHOULD BE ALTERED IN REGARD TO THIS MATTER.

I consider the Rivers Pollution (Prevention) Act, 1876, requires to be amended in many respects.

Firstly.—Power of entry.

Excessive use of water either as waste or as a means of diluting the liquids to be treated cannot be ascertained unless there is free access to works.

Secondly.—Facilities for obtaining samples of discharges.

Power ought to be given to compel the construction in easily accessible places of inspection or sampling chambers, both in the works and at the purification plant, and that such places should be kept in a condition of easy accessibility. The reason of this is obvious. In some cases a polluting discharge is seen to be taking place into a river, but owing to the depth of water in the river or the danger or difficulty to the inspector no samples can be obtained before the discharge has been stopped.

In some cases the discharging point is quite inaccessible and is placed below the surface of the river or in a culvert, or in even more difficult situations. As an instance, the point of discharge from one set of purification works is situate half-way up a weir (which is some 8 feet in height) and 4 feet from the side. The whole of the river falls over the weir in the vicinity of the pipe, and any discharge from the submerged pipe is mixed with practically the whole of the river before it can be seen. In this case a sampling chamber is placed on the line of discharge pipes, but it is very possible that surreptitious pipes join below the sampling chamber.

Thirdly.—Power to compel the removal of objectionable points of discharge.

Power should also be given to compel the removal of surreptitious discharge pipes. I hope to be able to produce a photograph of such a pipe. The existence of this "back door" has been known for some time, and it is also known that it is frequently used, but it has been impossible to obtain evidence of such a nature as would justify one in taking proceedings.

Fourthly.—Heavy penalties for the mis-use or non-usage of works.

In this watershed proceedings have been taken in several instances for the wilful mis-use of works. In these cases the purification plants were capable of giving fairly satisfactory results when legitimately used, but it was found that the accumulated sludge was surreptitiously discharged. The following table shows the length of time occupied by the various steps which, at present, it is necessary should be taken before a conviction can be obtained:—

Offence - - - -	10th March, 1904.
Reported to Committee	14th March.
Committee give firm two months' notice of intention to take proceedings	30th March.
Application made to Local Government Board for consent to take legal proceedings - - -	30th March.
Local Government Board held Inquiry - - -	6th May.
Local Government Board sanctioned proceedings -	30th June.
Sanction reported to Committee - - - -	11th July.
County Court - - -	23rd September.

Although the parties pleaded guilty the law allowed no penalty other than the granting of an Order to restrain from committing such offences. It will be seen from the table that it was possible for the firm to continue to mis-use the works for six months whilst proceedings were pending without penalty. The same holds good for non-usage of works. In my opinion it is ridiculous that the Local Government Board should need to hold an inquiry to see if means are reasonable, practicable, and available, with due regard to cost, etc., for a firm which has constructed purification plant, the offence into which inquiry is being held being the mis-use of such works. The maximum penalty ought to be very heavy.

Fifthly.—Procedure necessary to compel construction of purification works.

The following is the portion of the 1876 Act dealing with this matter:—

> "4.—Every person who causes to fall or flow or knowingly permits to fall or flow or to be carried into any stream any poisonous, noxious, or polluting liquid proceeding from any factory or manufacturing process shall (subject as in this Act mentioned) be deemed to have committed an offence against this Act.
>
> "Where any such poisonous, noxious, or polluting liquid as aforesaid falls or flows or is carried into any stream along a channel used, constructed, or in process of construction at the date of the passing of this Act, or any new channel constructed in substitution thereof, and having its outfall at the same spot, for the purpose of conveying such liquid, the person causing or knowingly permitting the poisonous, noxious, or polluting liquid so to fall or flow or to be carried shall not be deemed to have committed an offence against this Act if he shows to the satisfaction of the court having cognisance of the case that he is using the best practicable and reasonably available means to render harmless the poisonous, noxious, or polluting liquid so falling or flowing or carried into the stream.
>
> "6.—Unless and until Parliament otherwise provides, the following enactments shall take effect:—Proceedings shall not be taken against any person under this part of this Act save by a sanitary authority, nor shall any such proceedings be taken without the consent of the Local Government Board; provided always, that if the sanitary authority, on the application of any person interested alleging an offence to have been committed, shall refuse to take proceedings or apply for the consent by this section provided, the person so interested may apply to the Local Government Board, and if that Board, on inquiry, is of opinion that the sanitary authority should take proceedings, they may direct the sanitary authority accordingly, who shall thereupon commence proceedings.
>
> "The said Board in giving or withholding their consent shall have regard to the industrial interests involved in the case and to the circumstances and requirements of the locality.
>
> "The said Board shall not give their consent to proceedings by the sanitary authority of any district which is the seat of any manufacturing industry unless they are satisfied, after due inquiry, that means for rendering harmless the poisonous, noxious, or polluting liquids proceeding from the processes of such manufacturers are reasonably practicable and available under all the circumstances of the case, and that no material injury will be inflicted by such proceedings on the interests of such industry.
>
> "Any person within such district as aforesaid, against whom proceedings are proposed to be taken under this part of this Act, shall, notwithstanding any consent of the Local Government Board, be at liberty to object before the sanitary authority to such proceedings being taken, and such authority shall, if required in writing by such person, afford him an opportunity of being heard against such proceedings being taken, so far as the same relate to his works or manufacturing processes. The sanitary authority shall thereupon allow such person to be heard by himself, agents, and witnesses, and after inquiry such authority shall determine, having regard to all the considerations to which the Local Government Board are by this section directed to

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have regard, whether such proceedings as aforesaid shall or shall not be taken; and where any such sanitary authority has taken proceedings under this Act, it shall not be competent to other sanitary authorities to take proceedings under this Act till the party against whom such proceedings are intended shall have failed in reasonable time to carry out the order of any competent court under this Act."

The difficulties which meet a manufacturer are very great. The firm may be tenants either on a short or long lease; land may not be available on which to build tanks or filters, or only obtainable at a long price; the only available site may necessitate expensive engineering works; local nuisance may arise from the purification plant; difficulties of sludge removal; general first cost and annual cost.

Any or all of the above factors may be alleged by a manufacturer, and it follows that one firm may be at a much greater expense than another firm in dealing with a smaller volume of similar liquids, and yet results may not be satisfactory. At present, owing to the saving clauses in the Act, it is impossible to state either what standard must be attained or even to fix general principles on which plants should be designed or required.

In my opinion standards should be fixed subject to appeal to the Rivers Boards or central authority. The onus of proof that local or private circumstances prevent a firm constructing such purification plant as will enable them to meet the standard should lie on the manufacturer.

NECESSITY OF SAMPLES.

Under the 1876 Act it is not essential that samples should be taken, but under the Mersey and Irwell and the West Riding Acts any samples taken on works must be taken in duplicate or triplicate. In some cases it would be very difficult for an inspector to duplicate all his samples, especially in cases of surreptitious discharges. It ought to suffice that the inspector intimate that he has taken samples.

27678. The works in your watershed, I think, consist of paper works, calico bleaching, printing and dyeing, and brewing?—Those are the main works.

27679. Those are the main works?—We have others, but the others I have not thought it necessary to mention. There is coal washing and small trades which only result in a very small volume of liquid which I have not mentioned. These are the main trades which I thought were the essential.

27680. Have you a list of the works in the form of a table; it would be of value to the Commission?—I have not one with me; I could prepare you a list.

27681. We have that for the West Riding?—You mean a complete list of manufacturers who have purification tanks in one form or another.

27682. Under the different heads; so many paper works, so many calico print works, and so on?—Yes, I could do that.

27683. Then in two other columns, one with treatment and the other without treatment, and perhaps a third, going into the sewer?—I am very glad to say we have not a single works without treatment.

27684. They are all treated?—They are all treated.

27685. Are they what you would consider fairly satisfactory, I mean do they remove the bulk of the suspended matter or reduce it to 3 or 4 parts per 100,000?—They reduce it very considerably and you would see from the tables which I sent you that at times the whole of the suspended matter is reduced up to within 3 or 4 parts per 100,000. At other times the same works will be discharging a liquid containing much more suspended matter than that, and that is one of the difficulties which I have brought out, I trust, in the evidence with relation to all classes of works.

27686. We will deal with those when we come to the different works?—If you please.

27687. You give us here various manufactories. In the case of the newspaper works, wood pulp is used chiefly I think?—That is so, Sir.

27688. Is it the case that all solid matter which goes away from the wood pulp works is waste of valuable material?—No, Sir; a large portion is in my opinion valuable waste material, but there is a smaller portion which I do not think can be used. The major portion is clean waste and in many cases is recovered, but at the same works, where they recover and re-use a large portion of their pulp there is a small portion of their liquids on certain days which they cannot or do not re-use. That is because at the week-ends they what they call clean down or sweep up, whichever you like, and the floor-washings and other washings are dirtier liquids and the pulp which is recovered is too dirty to be re-used, so that at certain times of the week the liquids give a sludge which the manufacturer considers not advisable to re-use.

27689. Do you consider in that class of work that the waste from those particular works can be reduced to 2 or 3 parts per 100,000 of sewage matter by such treatment?—I do, Sir.

27690. Speaking generally?—Speaking generally; I think it can be if the tanks are sufficiently large; the principle allows the removal to 3 or 4 parts per 100,000. I might mention, Sir, that in the news paper trade, at least in the newspaper paper where to-day they are using practically nothing but pulp as their fibre giving material, at one time they used to use rags and the rag waters necessitated a plant to recover all their alkali, but the trade or the nature of the trade having altered in the majority of cases in the river watershed, rags are not used in making the news paper, so that that plant which they once had for the recovery of the alkali from their liquids is now lying waste.

27691. (*Sir William Ramsay*) Might I interpose; the word pulp is only used for wood pulp I suppose?—I think so, yes.

27692. When you speak of esparto you use the word esparto?—I think so, and they do in the trade.

27693. (*Chairman.*) With regard to the waste from the works where they use pulp, you say that can be recovered; the caustic soda can be recovered from the esparto at a profit?—Part of the alkali can be recovered. The treatment of the esparto, as I mention in the proof, consists in boiling with alkali. When the treatment has been carried on for some little time the alkali liquors are run off. Those liquors are evaporated. The grass is now washed with hot water, the washings are treated because they contain a considerable quantity of alkali. Further washings are necessary. Those further washings are still alkaline, and in many cases strongly alkaline, but the manufacturer often considers that the amount of alkalinity which is still present is not sufficiently large to pay for evaporation, so that in treating the esparto you get, as you might say, two classes of liquids, one of which is evaporated and I believe pays for treatment and more than pays for treatment, and another portion of the liquids of a similar nature but more dilute is, it is stated in the trade, so dilute that the cost of evaporation prevents them carrying out that method of treatment within reasonable bounds of cost. Of course the alkali liquors in addition to containing alkali contain a very large amount of organic matter. It is not purely alkali which they are treating, it is alkali partially in a free state and partially combined with the substances which have been removed from the grass.

27694. (*Sir William Ramsay.*) Is there any possibility of using methodical washing which would have the result that all the liquor would be treated?—That is a point which I have repeatedly discussed with men who hold, I believe, a high position in the trade, and I have suggested to them that their method of washing does not seem the most efficient method, but they say that in their opinion, it is.

27695. No doubt from their point of view it is sufficient, but from the point of view of the recovery of alkali, it is inefficient. From the point of view of treating paper it is probably all right?—Well, the one hangs on the other.

27696. Yes?—I asked, I remember, in one case, a manufacturer if he could not alter his method of washing which would in my opinion, not only wash his grass more efficiently, but at the same time would give stronger alkaline wash waters which would be probably worth while treating by this same method, but as he put it: "The mill is arranged on certain lines so that if I were to alter it, it would mean a very great cost in my general working methods and the operation of machinery and one thing or another." He could not alter his plant.

27697. It would be an initial cost, but he would gain in the long run?—I thought so, but he did not agree with me.

27698. (*Chairman.*) Would that mean using the dilute washings for the strong washings the next time?—It was on those lines that I made suggestions to him and also another method. They take the grass in large boilers and mix with alkali, boil with steam under pressure. The strongly alkaline waters are run off from those kiers. Warm water in the first case is run into the kiers full of the boiled grass and discharged. That goes on in the other washing in the same way. Well, I have noticed that as they ran off the kiers the water from any one particular washing varied in strength; that is to say, it appeared as if some of the water had been used to abstract the alkali liquors and another portion of the waters, although put into the kiers, did not come into contact with the alkaline substance, so that we distinctly obtained in one or two cases a variation in the strength of the water which they were running off from one particular wash; and it was on these grounds that I suggested that if they could mechanically stir their grass that they would probably have got a stronger liquid, that is to say the water would have been used more thoroughly in the washing itself.

27699. (*Sir William Ramsay.*) The obvious plan would be, would it not, in starting, to treat the esparto with a fairly strong alkaline liquid and run that off. Then the first washings would be used to dissolve soda in, to make a second alkaline liquid, instead of being thrown away or worked up by themselves, so as to make the treatment of a second lot of esparto correspond with the treatment of the first?—I would not suggest the first or second, but the later washings might be used in that way or the later washings used as the first washings.

27700. As the first washings?—As the manager put it to me: "My first object must be to get my raw materials on treatment perfectly white. Whatever I do, my object is to get my pulp at the finish free from all extraneous matter. That is my first consideration. My other considerations are secondary to that, and my first object must be to get my materials in the form that I want them, whatever methods I use in so doing." That seems to be his great object, and the means of arriving at that object are in some cases not as important as the object itself.

27701. I still think that he would economise and arrive at that object if he were to adopt methodical washing. The probability is that it has not penetrated the minds of the paper trade that this plan is possible which is perfectly possible in every other chemical operation?—It is a question of alteration of method in the works and their machinery is adapted for certain portions and they cannot alter it.

27702. (*Chairman.*) They will not change?—They cannot or they will not.

27703. From these works where esparto is used, that is the chief pollution from the esparto washing?—It is the chief pollution and the most difficult.

27704. Is there any lime?—There is the lime from the bleach; after boiling with alkali the materials are bleached and washed in what they call beaters. Those waters contain chlorine; and then they have the lime from the bleaching powder which they have to treat in some cases. Then, in addition, there is the lime from the causticising plant; that is to say, after they have evaporated their kier liquors and burned the residue, they obtain the alkali in the form of sodium carbonate, plus some carbonaceous matter. They dissolve the ash in water, get the soda in the form of sodium carbonate which they now treat with lime, giving caustic soda which they re-use and a large amount of calcium carbonate. That has to be treated or settled out; that is to say, the lime from the causticising. Summing up, you get the lime from the bleaching, the bleaching powders used, and you also get the waters used in washing the material after the materials have been bleached. These liquids have to be treated.

27705. Then are these liquids as a rule mixed together and then settled in one general tank, or are they treated separately?—The liquors apart from those evaporated, and the lime from the causticising plant which is sometimes treated separately, are generally all treated together, that is, sent down to the purification plant.

27706. Just as they come from the works?—Just as they come from the works, yes; the different processes are being carried on at the same time in different parts of the mill so that the waters from the different processes are coming down to the purification plant as they are being formed, all mixed together.

27707. And that is the case all through the day?—That is the case all through the day and night. I should like, if I may, to take this opportunity of stating or drawing your particular attention to the fact that paper works start perhaps at six o'clock on a Monday morning and they are continuously in work till mid-day on Saturday afternoon; that is to say, there is no stopping at night, and liquids have to be treated day and night which, if I may here also state, is a difficulty from the administrative point of view, in that more inspections have to be made during the night. You see, they are working normally at night, so one ought to visit normally at night. That is a difficulty in the paper trade, that they are working day and night although a part of their process is principally carried on during the daytime; that is to say the preparation of the raw material is mostly a day-time process, but the machines are used and the machine waters are being discharged day and night from Monday morning till Saturday afternoon without any interval or stoppage at all.

27708. Then do you think that the most efficient way is to mix all these liquids together? Have you any cases where attempts have been made to treat them separately?—No, Sir, we have no such works at all. It would mean, of course, an entirely separate plant, and it is very questionable whether that would be advantageous. I rather hold the view, as I state in the proof, that if the machine waters, I have described to you what I mean by machine waters, could be treated separately, that would result in a sludge which would possibly be re-usable, but when mixed—when that sludge is obtained from the whole of the mixed liquids—that sludge is not usable. You see, the part of the liquid which comes from the machines, what are called in the trade, back-waters, comes from a process in which the raw materials are all prepared, so those waters contain, as their principal impurity, suspended matter which is being carried through the machine wire. Now, in my opinion, many of these machine waters, if they could be treated entirely separately, would result in a sludge which could be re-used.

27709. The machine, if I may interrupt you, is the actual machine on which the paper is made?—That is so.

27710. The gauze?—The machine wire. My opinion is somewhat based upon the fact that in the paper trade, in the newspaper portion of the paper manufactory, the sludge which I state has been re-used at a large profit, is from the paper machine itself, the machine waters. Now if they can use it in the newspaper trade it seems to me highly probable that the sludge obtained from the machine waters in the kindred paper trade could also be re-used. I put it to manufacturers once or twice on those lines, and they say that they are so tied down by the terms of their contract that it is very often a matter of very great difficulty to them to introduce anything at all new. I might say, in connection with that, that it is only a matter of four or five years, four years since they started to re-use the sludge from the purification plant in the newspaper trade. That is the case referred to in my proof, where I state that there is a minimum of profit of £1,000 per annum. That has not been at work for more than four or five years. As a matter of fact, that was brought about by a prosecution which we had. This same firm used to discharge this sludge into the river in the middle of the night. We had reason to suspect that the sludge was being surreptitiously discharged to the river and finally evidence was obtained which warranted the committee in taking legal proceedings. A conviction

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was obtained, and an Order made restraining the firm from repeating the offence. The manager, recognising that the amount of sludge was very large, made experiments to see if it could be used in the mill. I had previously suggested to him the probability of the sludge being of value and useable if mixed with a larger proportion of pulp. Within six months the sludge was being re-used and resulted in a saving of at least £1,000 per annum. The manager stated that this figure could be mentioned publicly, but in my opinion the saving is a very much larger figure.

27711. (*Colonel Harding.*) Would you inform us what he used the sludge for ?—He used it, Sir, instead of using the original raw material; it displaced raw material.

27712. Did he mix it with his other ?—He mixed it with his other.

27713. He produced paper from it ?—He produced paper from it so that the amount of original pulp that he used was less on account of this re-usage of the recovered pulp. I should not be surprised if what happened in that trade obtains in these other forms of the paper trade. I think it is highly probable.

27714. (*Sir William Ramsay.*) I should like to ask what sort of relation does the lime obtained from bleach bear to the lime obtained from causticising the soda ?—Very similar, Sir.

27715. About the same quantity ?—I cannot give you the quantity; they vary so much, I could not give you any figures which would be reliable.

27716. Do they ever use the iron process of causticising the soda which would give them no residue; heating up the carbonate with ferric oxide and then extracting with water ?—I am not aware of any works where they use that process.

27717. That would give them no residue, and would save sludge from being produced ?—I am not aware that they have ever used it.

27718. Then another question: have analyses of these sludges ever been made; have you any notion of what they consist ?—I believe I have one or two, but I am not quite certain. I will look up my books; if I have, I will let you have them.

27719. (*Chairman*). With regard to brown papers, you have more difficulty as regards getting a satisfactory effluent ?—We have; yes, much greater difficulty.

27720. Is that on account of the purification works being less efficient ?—I would rather put it the other way, Sir, that it is on account of the more difficult liquids that have to be treated.

27721. You think that they have efficient works. Well, what proportion would the tanks bear to the daily output from these works ?—They vary.

27722. Would they be a day's supply ?—In some cases they would be at least a day's supply; in other cases they would be much more.

27723. But even then you do not get satisfactory results ?—We do not get satisfactory results. I do not think it is so much due to the principle of settlement or precipitation as it is that the liquids, even with settlement or precipitation, do not lend themselves to giving a satisfactory liquid, a non-polluting effluent. The nature of the liquid is such as will not give a satisfactory effluent even after efficient settlement.

27724. What sort of liquid is it that does not give a satisfactory effluent ?—I think, Sir, it is due to those liquids stated in the paragraph in my proof under brown paper. The first part of the process consists in boiling the fibrous materials with lime to remove dirt and grease. The kier liquors and wash waters are very grossly polluting and difficult of treatment. Those, Sir, to my mind, are the liquids which cause the difficulty.

27725. I was referring to the analyses, works D, in the lists which you have given us, the solids in suspension are reduced from 59 to 11·6, 16·8 ?—That is so.

27726. (*Sir William Ramsay.*) But there is very little reduction, if any, in dissolved solids ?—I do not think there would be any reduction in dissolved solids.

27727. (*Chairman.*) Then taking E, E is considerably better ?—E is much better, Sir.

27728. How do you account for that difference ?—The difference in the raw materials used.

27729. Entirely ?—Yes. The brown paper trade is broken up into a great number of separate styles. You get on the one hand the very heavy brown papers, what are called wrappers—the brown thick papers which are used for wrapping. You also get the heavy papers, sugar bag papers are those I refer to. Then you get the thinner brown papers, the butter papers and that class of paper which is used in shops for wrapping up light materials. Then you even come down as a final point to the toilet papers. All these brown papers necessitate the usage of a different class of the raw material, and it is according to the raw material which is first used that you get the strength of your original crude liquids to be treated.

27730. And then if you take I. your crude liquids contain 142 solids in suspension and the treated effluent varies from 2·4 to 15·6 ?—That is so. I do not doubt, Sir, that the crude liquids would also considerably vary. They do considerably vary. I have noticed when going round the works, that on one occasion the liquids which are being sent down to the purification plant are apparently much stronger than you will find on another visit.

27731. On the other hand, you have sulphuretted hydrogen from the 2·4 effluents and you had none from the 15.6 ?—That is so. One of my objects in giving you these tables was to show you the variable nature of the effluents obtained from the various works. I might point out works F. suspended matter 2·8, oxygen absorbed 2·68, after incubation slight H_2S. The following sample taken on February 19th, 1908, suspended matter 6, there is no H_2S. after incubation.

27732. And also you have none from the crude waste ?—We have none from the crude waste. As you see there was no H_2S. though apparently it was a very much stronger liquid.

27733. Your settling tanks, were they decomposing at the time ?—In my opinion it was due to that. You will find that all through, in all these different liquids, that some putrefy, others do not.

27734. (*Sir William Ramsay.*) Is any of this tank effluent filtered ?—Works H.; some of these are filtered effluents, Sir. But those filters, I think, are used more from the point of view of an attempt to strain off rather than from any attempt to biologically treat the dissolved impurities.

27735. In works H. is there a tank interposed between the crude liquids and the effluent ?—Yes, Sir. The treatment in works H. is settlement; in some cases precipitation followed by passage through a continuous filter. As a matter of fact, in those works, the settling tank capacity is equivalent to at least two days flow, probably more than that, but you will find, Sir, on reading those tables, that there is no certainty as to what you will obtain from the liquids.

27736. (*Chairman.*) I suppose the filter is a coarse one, is it ?—It is coarse; well, it is on the coarse side.

27737. 17·6 grains come through ?—Well, I should not call them particularly coarse, but the suspended matter is very fine in many cases. You will notice right through that there is no degree of certainty as to what you are going to obtain Some of them contain much more suspended matter than others, and some of them are putrescent on incubation, and others of them are not putrescent on incubation; there seems to be no certainty. Personally, I think it is due—I may be wrong—to the nature of the crude liquids being treated largely, to the condition of the sludge in the tanks, and the frequency with which they clean the tanks, which seem to set up more or less putrescence, and also the time of the year.

27738. How often do they clean their tanks ?—That is extremely variable. Some of them make a practice of cleaning them every week; some of them clean them after a lapse of a month or two; some even will go longer than that. But these brown liquids, I should like to mention here, Sir, are very often discharged quite hot. I took a sample the other day from a brown paper works and the temperature of that discharge was about 21° C. I cannot give you the proof of it, but I am firmly of opinion that those liquids on cooling down to ordinary temperature deposit an appreciable amount, several parts per 100,000, of suspended matter. That is after it passes through the tanks, which are of considerable size and perhaps equivalent to a day's flow.

27739. (*Sir William Ramsay.*) Can you give us any idea of the nature of the dissolved solids; are they largely lime salts or soda salts ?—Lime salts. If you consider, Sir, the nature of the raw materials in that brown paper trade, the rags, the tarpaulin, old waste tarpaulin, old waste paper, and imagine those liquids having to be treated with lime, I think you will have some idea as to what the impurities may consist of.

27740. (*Chairman.*) Then on what lines do you think there is a possibility of any improvement taking place in the treatment of trade waste; perhaps it is rather a large question; do you think any improvement is possible ?—I do. I think a very large improvement from the rivers point of view would result if the manufacturers were allowed or could obtain the right of discharging some particular portion of their trade liquids into the sewers. I think the remaining liquid would be more amenable to treatment by the manufacturer himself. I also think that a manufacturer could do more, and here is where I find difficulty in expressing myself; it might be used against me if we were taking proceedings against a manufacturer. I shall probably ask you to cut it out afterwards. We are limited in asking a manufacturer to improve his plant by the section of the 1876 Act which states that he must only use the best reasonable available means. Now a manufacturer would probably get a very much better result if he did not use the plea that I have stated, the best available means. I think in some cases the enlargement of his tanks, in other cases the addition of what one very seldom sees in manufactories, efficient filters, would undoubtedly improve his liquids. As you will see in my proof, Sir, in 1898 the Ribble Joint Committee took proceedings against a firm of brown paper manufacturers for turning in polluting liquids. It was before my time, but I am speaking now after having studied the case. It was suggested that he should increase his settling capacity, that is to say, increase his tank capacity. The defence admitted that the liquids were polluting liquids, and they also admitted that it was possible to get more efficient treatment, but in their case the cost of enlarging their tanks was such as, in their opinion, would throw an unfair burden on their particular trade. That case was tried in the High Court of Justice in the King's Bench Division, and it was held that the manufacturer had used reasonable means as qualified by the section of the Act for dealing with his particular liquids, so there was a distinct case of where a man could get more satisfactory effluents but he was limited by the Act in the expense to which he should go, so that although it may be possible to get more considerably improved treatment one has to consider in the present day as to how far he can go within the meaning of the Act, within the meaning of the section of the Act dealing with the cost and the effect of that cost on the trade and industry of that particular branch of the trade.

27741. Had they, as a matter of fact, improved their works since that action against them failed; have they carried out further works at all ?—No, they have not. As a matter of fact they are unsatisfactory liquids, they are variable, at times they change very considerably. I would like to give them credit that they use their present plant to the greatest extent except in one or two instances where the workmen have been at fault. It is a firm who, I believe, try to meet the pollution authorities. They have particular difficulties in that they are very much cramped for room. They would have to pull down an old building, but they naturally do not feel disposed to spend money on pulling down other people's buildings to erect tanks at considerable cost when they are covered by this judgment previously obtained.

27742. I suppose in this case the Local Government Board had given their consent to these proceedings ?—The Local Government Board, Sir, had given their consent to the proceedings, but I am not certain that the conditions were the same when the case was tried as when the Local Government Board had given consent. I may add that the channel by which the liquids were carried to the stream was constructed prior to the passing of the Act of 1876.

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27743. I only mention that to bring out this fact, that the administrative body were satisfied that means were reasonably available. I think the words of the Act are the Local Government Board shall not give consent unless they are satisfied that means are reasonably practicable and available under all the circumstances of the case for rendering the liquor harmless, and I must assume that they were satisfied ?—I am not certain that the tanks were not altered between the time of the Local Government Board Inquiry and the time of the case going to the court.

27744. If means were available at the time of the inquiry they did not cease to be available when they went to the court ?—I am not certain that they did not use those means which were available. I believe they had altered their tanks between the time of the inquiry and the time of this case going into the court.

27745. I was only meaning this; really it looked as though the court dealt with the question of fact which was intended, under the Act apparently, to be left to an administrative body, the Local Government Board ?—I think also, Sir, under the Act that the court have to be satisfied that means are available, have they not ?

27746. Does the Act say anything about the court being satisfied ?—The means which should be adopted for further treatment have to be considered by the court.

27747. That case shows that the court is willing to re-open these practical questions which the Government Department has already dealt with ?—The case was before my time. I studied very carefully the shorthand notes taken of the inquiry and it seems to me that there was some alteration between the time of the inquiry and the case going into court.

27748. But they got off, as I understand, on the ground that no means were reasonably available to prevent the pollution ?—No, Sir, they got off on the question that no means were practicably available with due regard to cost.

27749. Quite so, but that I take it is the meaning of this that means are reasonably practicable and available under all the circumstances of the case. They got off on the ground that that did not apply there, that is to say that no means were reasonably practicable and available under all the circumstances ?—That is so. They did not get off on the plea that means were not available, but on the plea that, under the special circumstances of that case, the means were not available.

27750. Quite so, but that is the Act. The Act says that the Local Government Board shall not consent unless they are satisfied that means for rendering harmless the polluting liquids are reasonably practicable and available under all the circumstances of the case, and that question presumably had to come before the administrative body, namely, the Local Government Board, who considered it I suppose and were satisfied, because they gave their consent ?—Well, I am not certain, Sir, that the conditions were not somewhat altered between the time that the Local Government Board had given their consent and the time at which those proceedings were taken in court; there was a lapse of time.

27751. I cannot quite see, if means were available at the time the Local Government Board gave their consent, they could cease to be available after ?—It is at question how far those means would result in efficient treatment. You will see there, Sir, that the volume from these particular trades is very large. I mention that. I particularly desire to draw your attention to that, that the volume from these paper trades is a very large volume that we have to deal with.

27752. (*Colonel Harding.*) The effluents from white paper works appear to be fairly satisfactory ?—Yes, Sir, from the white news paper works.

27753. In the example showing the tank effluent there is an exceedingly small quantity of suspended matter, and the oxygen is also low; I suppose you would say that these effluents were satisfactory ?—I should.

27754. What sort of streams are these paper works mostly situated on ?—The works A ?

27755. Well, are they on small tributaries or are they on the Ribble ?—They are on very small tributaries.

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In fact the effluent from works A. is the beginning of the river; that is to say that there is practically no river existent above the works A.

27756. Where do they get their water from ?—From the higher reaches of that same river.

27757. Then do I understand you that their effluent practically forms the river at that point ?—The effluent practically forms the river at that point in dry weather. In wet weather there is a considerable flow.

27758. As far as the white paper manufacturers are concerned you say the pollution is not serious ?—The pollution is not serious.

27759. And does it in any way interfere with the use of the stream by those lower down ?—I do not think it does.

27760. Then passing on to the makers of other papers where the effluents are far less satisfactory, you tell us that they are less satisfactory, among other reasons, because the crude liquids are themselves very much stronger and much more to be complained of ?—That is so.

27761. I rather gather, from the somewhat pessimistic view you expressed, that there seems to be no prospect of improvement ?—I should not like to say that; I do not hold such pessimistic opinions.

27762. You say manufacturers have put down certain tanks which do not bring about the results that you would desire ?—That is so.

27763. And that they do not carry out any further attempt to improve because they say they are covered by the clause which says that they shall not be called upon to do anything more apparently than other manufacturers in the district have done ?—In pressing these men to carry out increased works we have the judgment in this Almonds Case in our face. The Almonds Case is the case I have just been referring to.

27764. You say the decision of the Local Government Board, that there was no reasonable and practicable means is a bar to improvement ?—The decision of the court.

27765. Of the court, yes ?—I think it is.

27766. Well, now the court would judge I suppose by what was done at these various manufactories. If the particular manufacturer was doing what other manufacturers were doing, probably they would come to the conclusion that that was all that he could be expected to do, but is it not possible to induce a manufacturer to move a step further and to improve the results ?—That, Sir, has been our method for some years. We have been persuading manufacturers to increase their plant, to improve their method of using that plant, to increase the precipitants which they use and there is no question that in many cases the manufacturer is getting better results than formerly, but there is a limit.

27767. Before I go further, let me ask you what is the effect on the stream of those unsatisfactory effluents. They are large in volume you told me, and they contain a considerable quantity of suspended matter ?—They do.

27768. And it is to some extent, though apparently not to a large extent, preventable ?—To a considerable extent.

27769. Then what effect has it on the stream as it is now discharged ? Does it affect the use of the stream by manufacturers lower down ?—I think it does.

27770. Is any complaint made to you ?—We frequently have complaints. The complaints which we get are, as a rule, from districts situate near weirs.

27771. And is it the discharge of the weirs that they complain of ?—No, Sir. They complain of the odours arising from the river, particularly in the neighbourhood of these weirs, and where a road crosses or lies near to the discharge over the weir.

27772. The complaint then is not on the part of those who use the water, but on the part of passers by, who complain of the smell ?—We have it in both cases, from users and from the inhabitants on the stream.

27773. Then with regard to users; what is the point they regard as an inconvenience; is it the presence of suspended matter ?—To some extent, and it is to some extent due to the dissolved matters which cause a great deal of frothing and scaling. As a rule in our district, the waters are used for boilers and condensing purposes. In some cases they are used by manufacturers, but in comparatively few cases. In the majority of cases the manufacturers have built their works on a small side stream and have their reservoirs in the valleys of these smaller streams, using practically a clean water for their trade processes. We have not a great number of manuturers in the Ribble Watershed.

27774. How many of these brown paper mills are there in your district ?—Brown paper; in round figures I should say there are a dozen.

27775. Not more ?—No, I do not think there are more.

27776. And are the works carried on on a large scale by wealthy firms ?—In many cases, yes.

27777. Not by little people ?—No; in many cases by large firms.

27778. Have most of them ample space ?—No, they have not.

27779. Then the large volume of waste that they have to deal with would involve, for effective sedimentation and filtration, considerable space, would it not ?—In my opinion, to put down effective filtration would necessitate a considerable area of land.

27780. And have you reason to think that in most cases they have not that area ?—In many cases they have not.

27781. Would it not be possible for several of them to join together and deal with their trade refuse at some place common to them all ?—No, the works are some distance apart from each other.

27782. Then it seems to me, that before progress can be made, it is necessary that someone should consider, by analogy with other trades, whether effluents of that kind have been improved elsewhere; effluents of an analogous character; they cannot, of course, be the same ?—I am not aware of such other works,

27783. Have you formed an opinion yourself as to whether greater improvement cannot be brought about either by larger capacity of tankage or by some chemical treatment and by subsequent filtration. You said something about hot effluents probably depositing suspended matter when they cool. You said you thought that they might, but would it not be quite easy for you to ascertain if they do ?—Well, I will correct that, Sir, and say in some cases that they do.

27784. Would it not be possible in the laboratory to try certain experiments with the view to guiding these people ?—As far as possible, we do try to guide the manufacturers.

27785. You say that a great quantity of the suspended matter was very finely divided, and, therefore, difficult to get thrown down; would not chemical precipitation assist ?—It does assist and is very often used, but still it does not carry it all down, or else precipitants have not been used in the best method, or there may be some carelessness in using it.

27786. Can you give us the name of any public-spirited or exceptionally intelligent manufacturer of these brown papers who might be willing probably to try some experiments if the line were indicated to him ?—I have not suggested it to any manufacturer, but I fully believe that you are just as likely to obtain consent from some of these manufacturers as from any manufacturer, but the great danger is that they will fear that they are putting their head into a noose.

27787. Undoubtedly ?—And they are not very keen on granting that permission; they may land themselves in considerable expense.

27788. Unless something of this kind is done, what prospect of improvement is there at all ?—Well, Sir, I must admit many of our manufacturers have stated that the Commission have produced Reports, and we are going to have facilities given for discharging into the sewers; they are relying very strongly on that in some cases.

27789. You mentioned that just now, and it seems to me a point worth consideration. You said that if a certain part of the objectionable matter were passed

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not to the general tanks to be mixed with the easier matters to be dealt with, but were passed into the sewers, that some improvement might be brought about. Now, are sewers available there ?—In many cases.

27790. Then has application been made to the local authority for permission to pass these special kinds of effluents into the sewers ?—I do not think there has, because the local authority in one or two of those districts refuse to take any trade refuse at all ; it is very improbable that they would have any success if they did.

27791. Would not the volume of the worst parts of this effluent be so great as possibly to interfere with the treatment of domestic sewage ?—I think that it would be quite practicable to discharge some of their worst liquids to the sewers, and it would not affect the treatment at the sewage works.

27792. Has that opinion of yours been brought before the local authority at all ; have you suggested to any manufacturer that he should apply to the local authority with the view to transferring to the sewers the worst parts of his effluents ?—I have suggested it privately to the engineers of the different authorities, and they are very careful to say that : "We have not any trade liquid, and we shall use every endeavour to keep away from trade liquids until we are made."

27793. But you are aware, are you not, that in many other districts local authorities do in fact receive trade effluents, and that it is found generally to the advantage of the district that they should so receive them and treat the trade effluents *en bloc* mixed with the domestic sewage ?—I am aware of that, Sir, but I do not think that we should have much success.

27794. What kind of authorities are there in the neighbourhood of these mills ; are these mills near small towns or large towns ?—They vary very considerably ; in some cases they are situate in the heart of a town ; in two cases they are situate in the middle of a town. In the case of Darwen there would be no difficulty, from an engineering point of view, in discharging into the sewers. Sewers very often pass the works.

27795. Does it not seem, so far as these particular effluents are concerned, that that is the hopeful direction in which to work ?—I must admit that personally I have the very greatest hopes on those lines.

27796. Well, what movement is being made ; you say no application has been made ?—From my point of view, certainly, have been hoping that the recommendations of the Commission, which were made some few years ago, would be carried out, or at any rate that something definite would be done on the lines of the Commission's Report, either yea or nay.

27797. Does it appear to have occurred to these manufacturers to press the authorities ?—No, Sir ; they would apparently prefer for that pressure to come from an outside authority, such as the Local Government Board bringing in, or some person bringing in, a definite Bill, and for them then to have certain distinct rights, rather than that they should possibly have trouble with the local authority as the result of their appealing to discharge to the sewers.

27798. Has any movement of any kind, in your district, arisen among manufacturers or among the local authorities to urge the Government to take such action ?—I am not aware that there has. In many cases they have read the Report and the manufacturers have told me personally : "Well, we are hoping a very great deal on the lines of the Royal Commission's recommendations." They have also said : "When are these recommendations to be carried a stage further ?"

27799. It seems to me you have reached a condition of stagnation in this district ; everybody is hoping somebody else will do something, but no one is making the slightest effort at all ?—I am not aware that they have ever pressed anybody to bring in legislation, because they have been under the impression that such legislation was going to be introduced without any pressure from them. On the one hand we have this one difficulty, and here, Sir, is a point on which I feel very diffident in speaking, because, if we have to take a case into court and my opinion is expressed in public, at least my opinion is obtained from your Reports, I am very much hampered, and if you would allow me to speak my mind without any fear of that being put on your notes I could answer your question more definitely.

27800. We are anxious to be helpful to bring about improvement in connection with these trade wastes. We notice that in your district certain tanks are used and a certain amount of improvement brought about, but you tell us that the results are unsatisfactory. Apparently no effort is being made on the part of anyone to bring about better results, and we are anxious to see in what way they can be brought about, and in that way your opinion is exceedingly helpful to us, because you have large experience in connection with these particular works. I should like you to suggest to us what course could be taken to bring about improvements ? Can you make any experiments at all to guide you as to what would be helpful to these people ? Perhaps the most helpful suggestion we have had has been the one you have made that certain parts of effluents should be turned into the sewers. Now what particular effluent, from what particular branch of the work, do you suggest should be turned into the sewers ?—Those liquids which are obtained in the preparation of their raw materials.

27801. In the earlier processes ?—In the earlier processes.

27802. Well, is it practicable for them to separate that ?—I think it is.

27803. Is the volume of that part not too large ?—I do not think it is too large. That is, of course, a point on which it is extremely difficult to give an opinion, because you have to define which of those liquids could go and which could not go ; it would be a question of considerable discussion between the local authority on the one hand, the manufacturer on the other hand, and probably some deciding board to state which liquid might and which might not.

27804. Would there be any difficulty, do you think, on account of any obligation on the part of the manufacturer to return to the stream the water that he took from the stream ?—There would be a great difficulty, Sir, if he were to discharge the whole of his volume to the sewage works. But I am hoping, at least it has been in my mind, that the volume of his worst liquids would not be such as to affect riparian rights, but I do not think it at all possible in the Ribble Watershed for the manufacturers to discharge the whole of their waters into the sewers.

27805. I should think it would be very useful if you could give us the name of some authority within whose area there is a large paper mill, or several paper mills, in order that we might ourselves inquire as to the possibility of deviating into the sewers the worst parts of these effluents. It would be very interesting to see whether the parts remaining, after the withdrawal of the worst parts, were capable of effective treatment in tanks and filters ?—I could do that, Sir. May I mention here a matter which I had overlooked ? We had one case where a manufacturer did appeal to the local authority. The often quoted case of Peebles *v.* Oswaldtwistle Urban District Council is a case in point. A large firm of paper manufacturers made application to discharge to the sewers.

27806. That is the well-known case ?—That is the well-known case. Well, that is a case where it was held that the manufacturer at any rate would have to treat his own liquids.

27807. (*The Secretary.*) You mean that case decided that the local authority were under no obligation to construct sewers to carry trade refuse ?—I believe that was the ground.

27808. That was the decision in that case, and if the Recommendations of the Commission were carried out the local authority would have a duty to make a sewer, if necessary, and enlarge a sewer to take the trade effluent just as they have a duty to make a sewer to carry foecal matter ?—Quite so.

27809. There might be a difficulty at present in pressing local authorities, because they are under no statutory obligation to enlarge their sewers. It is perfectly practicable to treat the mixture of trade refuse, but there is no obligation upon them to make their works big enough, and so they object to do anything ?—That is so. The

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case of compelling the local authority to take a portion of trade liquids I am not aware has ever been taken.

27810. Oh, no, but it has been settled, as far as it can be settled, that there is at present no power to compel the local authority to take trade refuse ?—That is so, I believe.

27811. That is the law ?—In Peebles Case it was an attempt to discharge the whole of the liquids into the sewers, not what I am referring to, that the local authority should take a portion of their liquid into the sewers.

27812. (*Colonel Harding.*) The only thing that we might urge upon the local authority, for the benefit of the district, through which a stream passes, that they should, if it is possible, withdraw from these effluents the worst portion of them into their sewers ?—I am afraid, Sir, that will not altogether hold, because the boundaries of some of these districts are so situate that the discharges of the polluted waters is in a neighbouring district to the ones in which the works are situate, not in their own particular district.

27813. They are, of course, interested in the pollutions above them ?—In one case, the case of Almonds, which I have referred to, there is only a distance of half a mile from the top of the stream, which is formed by the discharge of one particular trade effluent.

27814. You find a difficulty in your district in pressing manufacturers to put down works which probably would become useless in the event of their being able before many months or years to connect with the sewers, and you tell us that the uncertainty of the position, at present, pending legislation, is barring all progress in your district ; is that so ?—Barring progress over and above a certain method of treatment ; that is to say, we have considered it inadvisable to take proceedings to compel manufacturers to put down extensive filtration areas.

27815. You say that your manufacturers and your local authorities are waiting for the decision of the legislature on the point as to whether they shall or shall not take trade effluent ?—I am waiting for it in order to be able to advise my committee.

27816. But you told us before that these people are looking forward and waiting for this legislation ?—Yes.

27817. (*Sir William Ramsay.*) The manufacturers are ? —Yes, in many cases manufacturers are waiting for this legislation on the lines of the Commissioner's Report. Meanwhile they point out they are using their tanks.

27818. (*Colonel Harding.*) The great point, a decision upon which is being waited for, is as to how far local authorities shall be compelled, and upon what conditions they shall be compelled to receive trade effluents ?—That is so.

27819. Well, that is the point apparently that it is desired to have defined ?—Quite so.

27820. And your manufacturers and local authorities do not seem to be pressing the Local Government Board at all to bring in such a Bill ?—No, I do not think they have taken any steps ; there has been no concerted action.

27821. The reason being, as I understand, that everybody has assumed that the Government will legislate in accordance with the recommendations of the Commission ?—I think so. And also they have taken it ; " Better let a sleeping dog lie. We have gone on in certain ways and the Commission is still sitting ; they will decide what they consider the best in the matter without any pressure from us."

27821*b*. What are your difficulties ?—The two difficulties are : On the one hand, will filters have a purifying effect over and above a straining effect, and, on the other hand, the possibilities of facilities for discharging into sewers.

27822. That point has not been proved practically yet, namely, whether it is a practicable thing to provide filters for these large works ?—No, it has not been proved, not in my opinion.

27823. No, I do not think it has ?—And we have not cared to take a case proving it is practicable until we know whether they will have to do it or not. That is my difficulty in advising my Committee.

27824. (*Mr. Stafford.*) Is the paper industry in a very flourishing condition financially ?—I should say not, when you say flourishing.

27825. Financially flourishing ?—Well, they are making a profit, but they are not making big profits. They tell me they are under very great difficulties as regards competition at home and abroad, particularly abroad.

27826. Is there not a danger of driving the paper industry out of this country if you drive them too hard in regard to sewage works expenditure ?—That is a point that certainly ought to be considered. Then there is another point to be considered. You remember in the white paper trade, the news paper trade, at one time they used rags, esparto and straw, and they put down a plant for the recovery of soda. In one works I know they did that. The conditions of trade have altered, and they do not use these materials at all. That plant has been scrapped. It may possibly be that other conditions of trade will also alter.

27827. If they were to fulfil your requirements would it not mean a very large increase of cost ?—Within the requirements of the Act.

27828. That is to say to put down new works and new methods of dealing with the trade refuse ?—Over and above settlement.

27829. That will cost a great deal more money ?—Yes.

27830. And there would be a danger of driving the trade out of the district ?—It ought to be considered especially in districts in competition with other districts.

27831. Most of these works are situated on streams in rural districts ?—No, Sir.

27832. Would you say not ?—I should say distinctly not ; some are and some are not.

27833. Do you think the majority are in urban districts—paper mills ?—No, the majority are not in urban districts.

27834. They are in rural districts ?—No, I beg your pardon, they are in boroughs or large urban districts.

27835. I was thinking of the question of sewer facilities. Sewer facilities in rural districts are not very great, so you have not got the sewer facilities available for the manufacturer ?—In some cases you would not.

27836. But you think the majority of the cases are rather in boroughs or in large urban districts than in rural districts ?—In many of the cases, I will not say the majority, but in many cases they could get to a sewer.

27837. But there are a great number of cases where they could not get to a sewer, they being situated in rural districts ?—That is so in some cases, but one must remember this, that in many cases where they are situate in rural districts, the trade possibly is only, comparatively speaking, a small trade ; that is to say if the works are sufficiently large to use a large volume of water, a large volume of water means a large number of hands which means more or less of a colony or a town.

27838. You will not get works which are using 1,000,000 gallons a day where there are only a few hands ; it is probably situate in a fairly central district, because the nature of the trade means that they employ a large number of hands ; that means more or less that it is in a populated district. What percentage do you think in your district, are situated in a rural district, and what percentage in an urban district ?—It is rather difficult to speak off-hand ; I am sorry I have not my list with me ; I should say 75 per cent.

27839. And urban ?—Urban.

27840. The District in which there are sewers ?—Yes And I should say taking it on the volume it is more than 75 per cent. ; taking the volume of brown paper trade or the brown and white, of liquids which might possibly go to sewers. Taking it on the whole volume reduced I should say there is considerably more than 75 per cent in urban districts.

27841. Do you think the capacity of the sewers in these urban districts is sufficient to take away trade wastes ?—You would have to settle which of their liquids should go to the sewers. You see you would have to break the trade up in a sense, what proportion do the worst liquids bear to the whole of the liquids, and I think in the majority of cases they could discharge to the sewer as at present.

27842. They could give considerable relief to the manufacturer through the sewers ?—I think so.

27843. Then for the rest of it, you would try and make the manufacturers put up increased works ?—Well, you would have to prove that the filters were efficient, then make them put down the filters. In the majority of cases tanks are efficient ; I mean to say tanks remove as much suspended matter as may easily be removed if the man is working his tanks properly.

27844. They take up the worst liquids, therefore it might be presumed the present tanks would take out what remains ?—If these works could be proved efficient ; assuming that.

27845. My point is, you cannot press these people too far to put up elaborate works of purification or you may drive the trade out of the district ?—You certainly cannot according to the present Act.

27846. You ought not to be given power to ?—If I were a shareholder, I should say not.

27847. You ought not, under any conditions, shareholder or not to have the power ? You do not want to drive trade away ?—Certainly it would be a very serious thing if the industries were hampered.

27848. So you have to be rather cautious in pressing these people to do too much and spend too much ?—On the other hand, Sir, you see in the Ribble Watershed, which of course one is speaking of, we are under peculiar difficulty. We have in the higher reaches of the stream these manufacturing districts ; they discharge finally into a fishing stream ; the river into which they discharge is a fishing stream—a salmon stream. On the other hand we have a stream which, after leaving the manufacturing district goes through a rural district, with very good residential houses, purely agricultural districts, and residents complain of the condition of the river ; so that on the one hand you have a district where you are turning out these liquids ; over the hill you have a residential district ; so it is a question as to how far the two interests clash. There is a map of the watershed published by the Commission in their Report on Tidal Waters. Well, judging from that, these streams, these tributary streams, the Darwen, the Calder, and the Douglas, which in dry weather consist very largely of the effluents from manufactories or from sewage works, finally discharge into a fishing stream. On the one hand you get a manufacturer complaining of his trade difficulties, on the other hand as an extreme you get a man with fishing rights on the stream which are worth something.

27849. Yes, but the trade is worth something too ?—Quite so. But those are the difficulties we have to contend with, and it is largely brought about by the small volume of water in those rivers, the tributary rivers.

27850. (*Chairman.*) Where do they get their water supply from as a rule for these paper works ?—They have their own gathering grounds.

27851. Would not that have to be returned to the rivers ?—Undoubtedly.

27852. Would not that prevent its being diverted into the sewer ?—It is a question whether the volume of liquids which they could treat in their own purification plant would not meet the case as to how much water they should discharge down the stream ; and whether the riparian owner would allow the worst part to be abstracted from the stream and discharged to the sewer.

27853. That would be optional with them ; as a matter of fact they would be bound to return the whole of it to the river if the riparian owners demanded it ?—That is so.

27854. (*The Secretary.*) Not if they have their own gathering grounds. If they collect water before it becomes a stream and divert it to their own works they are under no legal obligation then ?—They have both gathering grounds, and they also practically divert a small tributary.

27855. If they divert the river they must return that, but if they gather it on open moorland, water which has been scattered everywhere, gather it together and bring it in a pipe to their works the owners lower down have no right to that water ; certainly not ?—You see when a manufacturer is using say three-quarters of a million gallons a day you can understand, Sir, that he must have large reservoirs because he must have his water daily.

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27856. (*Chairman.*) The next class of works in your précis is calico bleaching, printing, and dyeing. Do you find, as a rule, that you can get more satisfactory results from that class of work as regards the treatment of your trade waste ?—I should not like to say that.

27857. Is the kier liquor a great difficulty ; you mention it here ?—Yes, it is ; that of course is in the bleaching.

27858. Do they mix that as a rule just as it comes from the kiers with the rest of the liquid ?—No, in some cases they discharge the kier liquor into a tank which they reserve for the kier liquors and the overflow from that tank discharges into the rest of the purification plant.

27859. So as to distribute it evenly over the day ?—As far as they can. At least the principle is that they first allow the kier liquors, in some cases that is, to go to their own particular tank and from that tank into the rest of the purification plant.

27860. Is that more satisfactory ; do they get better results that way ?—I should not like to say whether it is or not ; in some cases it appears to be. It depends how often they clean those tanks ; it depends on the general working of them.

27861. You mention at one works the uncertain rate at which the crude liquids were discharged to the tanks, the chemicals present, and the peculiar character of these, in that they contained a large amount of china clay, caused the effluents to be very unsatisfactory. Then in works like that, could not that have been improved by having a distributing tank ?—Well, Sir, those liquids are all discharged to the purification plant as they are formed. I do not think in this case it would be practicable to have a tank to which they should discharge the liquids and that tank should give an even discharge to the rest of the tanks.

27862. You say the removal in a solid form of the starches, gums and lakes is very desirable. Is that done as a rule at the works ?—Yes, Sir, to a certain extent it is done ; it is not done efficiently ; in some cases it is done more than others. I have had particular notice of a case of a manufacturer where we complain of the inefficiency of this plant and his liquids were very strongly coloured, very deeply coloured. The effect on a small stream was very very great. Amongst other improvements, in addition to filters, he altered his tanks and increased his filters, but the greatest improvement, in my opinion, that he carried out was this, shall I call it internal removal of matters, that is to say matters which he removed in the mill itself and which he prevented going down his sewers. His crude liquids were very much less difficult to deal with after he had removed those matters in the mill than they were before he removed them in the mill and when he sent them down to the purification plant diluted with the other waters.

27863. Having found that improvement you have impressed that improvement upon other manufacturers, I presume, to work them up to it ; is there any reason why that should not be done ?—I think perhaps it is more expensive ; it is more expensive ; it means that instead of turning on a tap and washing large boxes and one thing and another, letting the water go, somebody scraping them out and putting it into a separate tub and then removing that tub.

27864. It means less sludge in your actual works to remove ?—Quite so. It is more difficult ; it requires more attention in the works, shall I say.

27865. Have you any works where they are recovering the various products by themselves. I see you mention indigo here as one where the indigo waste has been recovered at a profit ?—Yes.

27866. Well, is there anything else that can be recovered in the calico printing works, soap for instance ?—I do not think we have a single case where soap is recovered in the form of the oil. From the amount of the soap used I do not think it could be effected. They do not do it. In the printing and bleaching the amount

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of soap used is quite different from the soap used in the woollen trade.

27867. You have no cases where soap is recovered ?—No ; we had one case, Sir. Perhaps it would be of interest for you to know that a man did put down a soap-recovery plant, but after putting down his soap-recovery plant he found that his soap bill immediately was reduced, as the amount of soap used in the works was considerably less than formerly ; I am told this by the man himself, I have no doubt it is correct, the amount of soap used was very much less after the soap liquors went to his soap-recovery plant than it was before. That is to say before the soap tanks existed there was a large amount of soap purposely wasted and sent down the sewer. That has nothing to do with purification.

27868. No, but that was a distinct advantage to him to put down the soap tanks ?—Undoubtedly ; well it stopped something going on inside the works which ought not to have existed.

27869. I suppose the same thing would apply to taking starch out in the works in the solid instead of sending it all down the drains ?—I want to correct any wrong impression I have given you, when I spoke of these soap tanks. The manager in conversation distinctly gave me to understand that somebody had been on purpose wasting soap which would have been found out when they put down the seak tanks ; it was not a question of using less soap in the works.

27870. I understood that ?—I thought your question as to the removing of the starch was on the same lines.

27871. It is on the same lines in a way. Supposing the starch mixture is a bad one, then in certain instances it goes down the drain ; if it is not allowed to go down the drains it appears on the waste heap ?—I am not aware of such a case, but I can quite imagine it.

27872. That is rather a reason for recovering soap ?—If there is sufficient soap to be recovered, but I do not think it would pay ; the amount of soap used I do not think would pay for its recovery.

27873. Have you ever had any works attempt to recover anything else besides the indigo ?—The soda ; in one or two cases they are recovering soda from the mercerising waters. In another case, many years ago, they attempted to recover chrome, not from bleach waters but from dye waters. That has been given up.

27874. It does not pay ; or what is the reason why it is given up ?—I believe that had something to do with it ; it would not pay, and the firm gave it up. I should not like to give their reasons why ; I should not be certain of the ground. Some people would say it was given up because there was a certain amount of smell produced. I never heard them say that, but still there is a strong possibility that it has something to do with that.

27875. (*Sir William Ramsay.*) Are any of the streams darkly coloured owing to calico printing works ?—Yes.

27876. That does happen ?—Yes, it does.

27877. Have experiments been made to see whether these colours could be thrown down by sulphate of alumina ?—Yes.

27878. And I suppose they are successful as a whole ?—They are not completely successful ; after the addition of sulphate of alumina, at present in the form of alumina ferric, their liquor is still coloured, highly coloured.

27879. Do such coloured waters give rise to complaint ?—We have complaints about the river because it is thought, when the river is coloured, that it must be something very objectionable.

27880. (*Mr. Stafford.*) Are many volumes of water used in this calico bleaching ?—Yes, very large volumes.

27881. Do you think unnecessarily large volumes ? Is there great waste ?—I would not like to say that ; the manufacturer would probably say I did not know his business ; I am not a calico bleacher.

27882. But there does seem a very large volume of water used in this bleaching ?—Oh yes. I know one bleach works where they are using 3,000,000 to 5,000,000 gallons a day ; in another case, which I refer to, their private reservoirs cover over 17 acres of ground ; you can imagine the volume of water which they are using.

27883. That seems a special characteristic of the trade of your district that the works involve such a very large volume of water, both in connection with paper making and in connection with calico printing ?—That is so ; the large volumes which they use and the small volumes of water in the streams.

27884. (*Chairman.*) With regard to brewing, I see you suggest that there is a satisfactory process which has been carried out for dealing with brewery waste ?—In my opinion, yes. We have only two breweries which do not discharge to the sewers and, as a matter of fact, I believe, they are two of the smallest breweries we have in the district. They are some little distance from the sewers, sufficiently far to be at present unable to be connected to the sewers, and so they have to deal with it in their own purification plant. In the other cases, where the volume is larger, they all go to the sewers. These two cases of breweries, I think, with a slight extension of the Act as regards the money-spending powers, would be able to deal with it.

27885. What is the process that they have adopted ?—Precipitation and filtration.

27886. Filtration ; this is through sand ?—In one case they have a filter 6 feet deep which we have complained about, and which they are now about to alter. They have taken out cooling and condensing and surface waters.

27887. Is that a percolating filter ?—A percolating filter, but the results are not yet obtainable. I fully believe that we shall get, judging from what they did previously, very decent results. In the other case the waters which go through the filters are fairly well purified. There are some liquids which they cannot get to the filters and those have an effect on the stream, but I believe that by filters you can get an efficient treatment.

27888. They precipitate first ?—They precipitate first.

27889. And what do they precipitate with ?—Alumina ferric. At one time they used to add sludge, sewage sludge, but they have given that up for several reasons. The smell from the works was very objectionable, they were rather afraid of it in the brewery. There was a good deal of uncertainty as to the rate at which they added the sewage sludge, and generally it did not work. Largely on account or partially on account of the unsatisfactory attention that was given to the plant.

27890. In your proof you say manufacturers as a whole have been desirous of removing the suspended matter from their trade liquids, but the necessity of pumping, the provision of sufficient settling space, the difficulty of running off top water without running off sludge, the difficulty of sludge removal, can be overcome only at considerable expense. Do you mean by that that they have not really attempted to do more than simply remove the suspended matter ?—Remove the suspended matter and the matter which may be removed by precipitation.

27891. And beyond that, does that mean a very big expense ?—The doing of that means a very large expense.

27892. I take it you do not see your way to getting much further at present ?—We want something a little bit more definite to go upon before we take the next step.

27893. But I suppose that has made an enormous improvement in the rivers ?—I do not think there is any question about it, Sir ; I believe doing that has completely altered the nature of the rivers. I mean to say, if you take any of these districts where these works are situate, and the man for some reason or other, turns his crude liquids into the stream, you would be astounded at the difference.

27894. If you went back to what you were before, you mean ?—Yes ; you let a manufacturer have free play for a week in our district ; that is to say, give them grace and say : " Do as you like ; " or if by some means they all had a breakdown at the same time and could not treat their liquids. The effect on the stream would be most marked.

27895. If you could get the manufacturers up to that mark of removing their suspended matter to a great extent as far as so many grains per gallon, would that make a further enormous improvement in the rivers ?—I should not like to say an enormous improvement, Sir.

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27896. You think you have got that now ?—I think it would make further improvement, but it would not make anything like the improvement which has been made already.

27897. Could you give us any idea of the proportion that they could improve their effluent, to the extent of two or three grains to the gallon ? I mean to say, that they are turning in only two to three grains to the gallon now ?—I have tried to classify them in the news paper trade ; they seem to get it there.

27898. Except the brown paper ?—With the brown papers we cannot get it down to that. Where they are using much esparto they cannot ; some of the bleach works are fairly free, and some of the dye works are fairly free from suspended matter. There is a case which I draw your attention to, works O ; I have only given you very few analyses there, Sir, but as a rule they are final effluents, containing very little suspended matter. As a rule they contain very little, but it has an effect on the stream, a marked effect.

27899. And you have sulphuretted hydrogen formed ? —We have. That is the cause of the trouble. There is another works which I have not given you, where the suspended matter is reduced. This table I have not sent in, because I did not want to give you more than you required, but there the effluents we get very seldom contain more than 4 parts per 100,000, but those effluents very often putrefy.

27900. Do you generally get sulphuretted hydrogen at these particular works ?—In summer we do.

27901. Is it a question of the tanks being cleared out regularly ?—To some extent ; it is also a question as to whether their liquor is not naturally putrescent or putrescible. That is to say, the starches and the gums which they contain would putrefy. In one case they use practically nothing but river water, but that river water contains —certainly it is not a pure river water, but it is certainly better than they turn it out ; I think between the two of them they make it putrescible.

27902. At these particular works do they remove the starch inside the works ?—As far as they can ; at least they say they do. They say they do, but I cannot say that they do because we do not make a practice of going into the works. If we went in, and said : "Are you removing this starch ?" the man would say : "Oh, yes, we shall remove that when it is ready to be removed." If we were standing watching him, he would remove it. It is exactly the way they work the tanks.

27903. (*Sir William Ramsay*). May I ask you whether lime has ever been used for brewery refuse instead of alumina ferric ?—They are using both lime and alumina ferric.

27904. Both together ; a mixture ?—Yes.

27905. May I also ask, have you any experience of the purification being effected by mechanical pressure filters ? —No, Sir, I have not.

27906. (*Chairman.*) Then the next point that we come to, Mr. Halliwell, is the question of standards. Would you like to see standards fixed ?—I should if it were practicable ; it is a big "if," Sir.

27907. It would help you in your work ?—Yes, Sir. If it is possible to fix standards, I think standards would be extremely useful.

27908. You can see considerable difficulty ?—I can see considerable difficulty.

27909. What are your chief difficulties ?—I look upon a standard as such that, if you exceed that standard, you pollute your river. That is to say, you fix your standard, quite apart from the means which are available for dealing with liquids, you look at it alone. If you exceed the standard you pollute the river, so that your first consideration is, fix your standard so that if you exceed that standard your river is polluted. The next point is, is it practicable, having fixed that standard, or at least is it possible to put down works for dealing with liquids so that those liquids do not exceed the standard.

27910. Under all circumstances ?—Under all circumstances. Take the two things separately. A standard must to my mind mean that, exceeding that standard you pollute your stream. If you do not exceed that standard, you do not pollute your stream, so that you must consider the standard as quite apart from the liquids you are going to have to deal with. That to my mind is the meaning of a standard, a standard of what will pollute, and what will not pollute ; not a standard of method to be adopted, but rather a standard which means exceed that standard you pollute your stream ; come within that standard, you do not pollute your stream. Now, that is the first thing you have to consider. The next point is, is it possible to put down works so that those works will produce a liquid which comes within that standard ? Is it possible to fix the principle which will allow of you treating your liquids to come within that standard.

27911. You are speaking now of works where you have plenty of room ; supposing you fixed your standard for works where there is plenty of space to put down sufficient works ?—I consider, if you fix a standard, that the meaning of standard only allows the pollution of the river to be considered, so that the question as to what treatment can be given hardly arises.

27912. Would there be any difficulty in a standard as regards suspended matter ?—I do not think there would.

27913. (*Colonel Harding.*) You told us just now that it was not practicable for these people to reduce the suspended matter below the amount shown in those Tables, and yet you are suggesting to us now that it would be possible to fix a standard for suspended matter ? —I must have misled you, Sir. I think that it is theoretically possible. That is to say, if you will not limit, as the present Act limits, the means to remove the suspended matter.

27914. You think it is possible, but you doubt whether it is practicable ?—Under this present Act, yes.

27915. Well, would you advise that in a new Bill a standard for suspended matter should be fixed ?—I would.

27916. Suppose, for instance, that a standard were fixed, that an effluent must not contain more than 3 parts per 100,000. Well, your people who are making white paper might produce an effluent of that character ?— Quite so.

27917. But would it be practicable for the brown paper manufacturer to produce an effluent containing only 3 parts per 100,000 ?—If you will not limit the pressure you can bring to bear on him as to what method with regard to expense.

27918. I am talking about practicability ?—I think it quite practical to reduce suspended matter to within small amounts, say 3 or 4 parts.

27919. It is possible, but do you say it is practicable to do it ? I thought the whole drift of what you were telling us was that it was not financially practicable to bring down suspended matter below what it is at present brought down to, unless they had large additional tankage. The whole thing turns on practicability. What is the use of fixing a standard if it is not practicable ?—I like standards theoretically, but I am not sure in my own mind that standards could be made.

27920. Do you advise that standards be fixed, from your experience, having to administer these matters in connection with rivers pollution ; suppose you had a standard that not more than 3 parts per 100,000 suspended matter should be allowed to go into an effluent. Would it be possible to bring people to that ; would that be really useful to you ?—I think it would ; I think they ought to be brought to that.

27921. You would have a latitude to allow people to send a larger quantity of suspended matter in if it was found to be ruinous to the trade to reach the standard ? But you think it would be useful to have that standard ? —I think it would be useful to have that standard.

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27922. Even if the standard were a elastic one, and if your board had power to relax it in certain cases——? —If we had power to relax it I think it would.

27923. You think the existence of a standard itself would be something to aim at ?—It would be something to aim at certainly.

27924. (*Chairman.*) You would relax it in the case of works that were not able to come up to it, would you ?—Well, Sir, I rather put it in this way. I say that in my opinion a standard should be fixed subject to an appeal to the board or a central authority; that is to say, assuming you fix your standard, then the onus of proof that that standard cannot be obtained should lie on the manufacturer; that is to say, you fix your standard as regards both suspended matter and other matters, a man exceeds your standard, and the onus of proof should be on that manufacturer that he cannot meet your standard, and he should prove to the Rivers Board his reasons why he cannot meet that standard. If the Rivers Board thinks his explanation a reasonable one, they should have power to accept it. The standard still remains, but he is not proceeded against because they are satisfied with his explanation. If the Rivers Board are not satisfied with his explanation as to why he cannot meet the standard he should have a right of appeal from them to, say, The "Central Authority." If the Rivers Board or Central Authority consider that it is practicable for him to meet the standard, or at any rate to do better than he is doing in his attempts to meet the standard, then he ought to be liable at law for penalties.

27925. But then are you not rather coming back to what you have now, which is the best practicable and available means ?—Yes, but at present under the best practicable and available means it is difficult to define what they mean. The practicable and available means differ practically in every case.

27926. So they would in this case, would they not ?—Well, the onus would be on the manufacturer to say why he cannot meet it.

27927. (*Sir William Ramsay.*) Would it not simply mean putting up a new Court of Appeal, namely, the Central Authority, in place of the Rivers Board ?—I think it goes further than that, Sir. I think the onus being on the manufacturer he would have to show why it is financially impracticable for him to do it. Now, it is a very different matter for him to do that—to show why it is financially impracticable—than it is for a Rivers Board to show that it is financially practicable for him to do it.

27928. (*Colonel Harding.*) You like it because it would shift the onus of proof from the Rivers Board to the shoulders of the manufacturer ?—Well, Sir, it does shift it from one shoulder to the other.

27929. That is why it would be convenient ?—Well, you cannot lay down to-day a principle as to what a manufacturer should do; you cannot lay down a principle that a man should lay down both filters and tanks, because he has peculiar difficulties in his own case.

27930. Yes, but the point is this; whether it is better to leave the law as it is, the reasonable and practicable clause—to rest on that—or whether it is better to have a certain standard to aim at, and with power to the administrative body to relax it where necessary ?—In my opinion, the latter would be very much better.

27931. In any case you quite appreciate the necessity for giving power to administrative bodies to relax it in certain cases ?—I do.

27932. (*Chairman.*) Of course, as you know, in the Mersey and Irwell Act the financial clause is removed ? —Yes.

27933. That is to say, that the financial question does not come in at all ?—Yes.

27934. Supposing you removed it in this case, simply leaving the practicable and available means as regards the treatment of trade waste, would that be satisfactory ? —I think it almost comes down to this, if you remove the financial clause and leave the practicable and available clause, that the manufacturer knows the ins-and-outs as to whether it is practicable or not better than you do; he knows whether he can obtain certain lands or not; he knows the owner of those lands, he knows whether he can get at them at all. The Rivers Board cannot say so definitely as he can; he knows his own possibilities.

27935. As regards buying land that is merely; not as regards the works. You can prove that the works are unsatisfactory; the onus of proof as regards the purification works for the Rivers Board would not be difficult would it ?—No, I would leave the onus of proof that they are polluting, and that the works are still inefficient on the Rivers Boards, but the onus of proof as to whether it is possible for the manufacturer to alter or increase his purification plant should be on the manufacturer.

27936. The onus of proof, I take it, up to now with you, has been the financial difficulty ?—The financial difficulty, which has a bearing on the methods which he can use.

27937. But do you think in any case you would compel a manufacturer to buy land to put down purification plant ?—I think he ought to be given facilities where necessary to obtain land, the same as a local authority has.

27938. If you gave him facilities, would then the present clause be satisfactory to you—the best practicable and available means ?—Leaving out the question of financially practicable, Oh, yes. That makes a great difference.

27939. If you give him facilities to buy land ?—If we gave him facilities to buy land, but you must take out those words "financially possible" and its effect on the trade. You see we have made a practice of asking manufacturers to remove suspended matter from his trade liquids; we try to compel him to remove suspended matter. The court says "No, he has no available means to do it. If this be so, how can we ask him to go further and remove dissolved matters ?

27940. With regard to the power of entry, you say under the present Act we have no power of entry, and you suggest that you should have greater powers ?—I do.

27941. Would those be confined to the purification plant, or to the works themselves ?—To my mind it ought to be carried further than the purification plant; it ought to be carried to the works themselves.

27942. You ought to have power to go into the works ? —Yes.

27943. At any time you like ?—Yes.

27944. Day and night ?—Day and night, if they are working.

27945 (*Sir William Ramsay.*) Is not that the case under the Alkali Act; has not the inspector power of entry at any time ?—I cannot say definitely, but I think he has.

27946. (*Chairman.*) Do you think manufacturers would object to that as a rule ?—I do not see why they should.

27947. Of course, it would not be only for you; it would be for your subordinates as well ?—Quite so. I would not allow anyone to go on those works; he would have to show proof that he was entitled to go on those works.

27948. Why should that not be confined to the purification works only ? That would not give you all you want ?—I do not think, Sir, it would meet the case. I think a manufacturer would be able in some cases to discharge liquids from his works, and you ought to have power to go into that mill and see if the liquids are being sent to the purification plant. I have a case in point. A manufacturer pumps his liquid to his purification plant; his works are built over a culvert; that manufacturer discharged liquids into the culvert; that is when his pump well is overflowing. It never went into the purification plant. Part of it may be going one way, and part another. There was a discharge of polluting liquids from the mill and not from the purification plant. Unless you had power of entry you could not get into those places.

27949. If you had that power of entry to the purification plant, would not you have discovered that it was not going ?—Part may have been going and part not ; part of his liquid not going to his purification plant.

27950. You would be able to discover that by going into the works ?—Yes.

27951. You would have to visit the outlet in any case, I presume, and take a sample, and so on ?—I think the Act ought to be that you can get it at the nearest point of its entrance to the stream, or have power given of opening up to see where certain liquids go. In this case which I have in mind there is a culvert into which in dry weather the whole of the river is diverted. At the top end of the culvert there is a turbine. It is almost impossible to wade in that culvert ; there are holes which would take you up to your neck, overhead in some cases. Well, there are points of discharge in that same culvert ; there are about half a dozen points of discharge which are visible from a point inside the works. They are not practically approachable unless you have power of entry on to the works. I think you ought to have power to get to those places.

27952. Would it be possible to have power in special cases from a court ?—I think, Sir, that would be a very objectionable thing to have to do. You would have to obtain power from a court for reasons which you could not prove. I mean to say, if it was a suspect, you would have to go to court and ask : " Will you give me power to do this, because I suspect someone of doing it ? " The very fact of your getting power of court to enter would for the time being probably prevent a man from using those pipes. We have had very great facilities given to us by manufacturers, very great facilities in the majority of cases. They allow us really to go where we like. As far as possible we are on good working terms with them ; we try to help them out of all their difficulties, and they do not put difficulties in our way, but I am certain in one or two cases it is impossible to get to the pipes which I am certain exist, unless you have power to enter on the works.

27953. (*Colonel Harding.*) You would not expect power of entry to walk all about the works ; merely power of entry to reach the point of discharge ?—Or suspected discharge.

27954. Yes, and you probably would like some compulsion to make the points of discharge accessible ?—I should, Sir, very much.

27955. That seems to me the important thing ?—That is so.

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27956. You know that in certain towns where they allow the effluents to be connected to sewers they insist also on the provision of a man-hole which is at all times accessible to the servants of the corporation for the purpose of inspecting what is passing at the time ?—That is so.

27957. That is so at Leeds, and I believe at Manchester, and other places ?—In the majority of towns.

27958. It would not be a very serious thing to ask a manufacturer to make the outlet of his trade effluent into the stream accessible, either through a man-hole or otherwise ?—Yes, Sir, but I think we ought to be given power to make sure that he has no others than that one that he states he has.

27959. If a provision was made that any outlet for trade effluent into a stream shall be made accessible by means of a man-hole or otherwise, that would probably meet the case, would it not ?—Supposing there is one which is not accessible ?

27960. Well, then it would be illegal ?—But how are you to prove it exists unless you have power of entry?

27961. It would then be illegal to have any trade liquid discharging into a stream unless the point of discharge was accessible and evident ?—I think you ought to have power to prove the question then, because how are you going to prove that he has those illegal points ?

27962. You cannot provide for everything in law.

27963. (*Sir William Ramsay.*) What is the difficulty as regards power of entry which exists in the case of the alkali trade ?—I do not see why it should not exist all round.

27964. (*Colonel Harding.*) Your point is that in certain cases there is evidently polluting discharge, but you cannot say from whence it comes. You cannot say it comes from A's mill, because it may possibly be coming from B's mill, and you cannot get to the point of discharge to find out who is to blame ?—That to a certain point ; and also you may have one mill alone, where there are what I should call surreptitious points of discharge ; the effect on the stream may not be very very great alone, but you cannot get to that point at all. He may have a dozen of these different points.

27965. It seems to me that what is wanted is something analogous to the town conditions that where the trade effluent passes into a sewer it has to pass through a man-hole which is to be accessible at all times to the officials of the Local Authority ?—Yes, with a penalty if the liquid is discharging at other points.

27966. That is an illegal position ?—But you ought to be able to prove these positions.

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ANALYTICAL TABLES HANDED IN BY MR. EDWARD HALLIWELL, CHIEF INSPECTOR TO THE RIBBLE JOINT COMMITTEE.

Parts per 100,000.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Oxygen Absorbed.			In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free	Alb.	In 15 minutes.	In three minutes.	In four hours.	Alb. Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours	Oxygen absorbed three minutes.	Odour.
WORKS A—WHITE PAPER.																		
W. 87	Jan 5, 1903.	Crude liquids	104	100	204	19	35	54	·02	·12	3·7	—	20·0	—	—	—	—	—
W. 88	„	Tank effluent	2	1	3	7	21	28	·01	·06	·10	—	·40	—	—	—	—	—
W. 1818	Nov. 8, 1906	Crude liquids	77	62	139	27	41	68	--	—	—	4·84	21·0	—	·44	2·28	4·76	No H_2S.
W. 1819	„	Tank effluent	1·2	·4	1·6	14	25	39	—	—	—	·40	1·72	—	—	—	·40	No H_2S.
W. 2125	June 27, 1907	Tank effluent	1·2	·8	2·0	10	21	31	—	—	—	·38	—	—	—	—	·20	No H_2S.
W. 2700	Aug. 24, 1908	Tank effluent	·8	·4	1·2	9	23	32	—	—	—	·30	—	—	—	—	·20	No H_2S.
WORKS B—WHITE PAPER.																		
L.	Oct. 17, 1900	Crude liquids	16·8	22·6	39·4	36	68	104	—	—	—	—	—	—	—	—	—	--
L.	„	Tank effluent	1·2	·4	1·6	12	36	48	—	—	—	—	—	—	—	—	—	—
L. 1178	Oct. 11, 1905	Tank effluent	·6	·6	1·2	12	44	56	—	—	—	·52	—	—	—	—	·48	No H_2S.
L. 2727	Mar. 2, 1908	Tank effluent	1·0	1·2	2·2	20	48	68	—	—	—	·62	—	—	—	—	·48	No H_2S.
WORKS C—WHITE PAPER.																		
L. 782	Feb. 22, 1905	Tank effluent	·0	·2	·2	15	40	55	—	—	—	·66	—	—	—	—	·70	—
L. 1448	April 6, 1906	Tank effluent	1·8	·4	2·2	10	30	40	—	—	—	·50	—	—	—	—	·52	No H_2S.
L. 1976A	Jan. 4, 1907	Tank effluent	1·0	·6	1·6	10	28	38	—	—	—	·34	—	—	—	—	·34	No H_2S.
L. 2293	July 15, 1907	Tank effluent	2·0	1·8	3·8	11	28	39	—	—	—	·66	—	—	—	—	·64	No H_2S.
WORKS D—BROWN PAPER.																		
W. 95	Jan. 9, 1903	Crude liquids	35	24	59	29	42	71	·15	·30	3·3	—	10·9	—	—	—	—	—
W. 96	Jan. 9, 1903	Tank effluent	4	7	11	23	40	63	·12	·53	1·5	—	5·0	—	—	—	—	—
W. 1286	Aug. 29, 1905	Tank effluent	2·0	1·6	3·6	31	56	87	—	—	—	1·32	—	—	—	—	1·40	No H_2S.
W. 2279	Oct. 11, 1907	Tank effluent	7·2	9·6	16·8	30	60	90	—	—	—	2·16	—	—	—	—	2·10	H_2S.

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WORKS E—BROWN PAPER.

W. 123	Jan. 30, 1903	Crude liquids	23	14	37	24	45	69	·05	·08	2·6	—	5·8	—	—	—	—	—
W. 124	Jan. 30, 1903	Tank effluent	1·9	·8	2·7	10	43	53	·04	·04	·60	—	1·4	—	—	—	—	—
W. 992	Jan. 16, 1905	Tank effluent	·6	·4	1·0	53	77	130	—	—	—	1·48	—	—	—	—	1·60	No H_2S.
W.1757	Oct. 4, 1906	Tank effluent	2·4	3·0	5·4	20	48	68	—	—	—	·96	—	—	—	—	·86	No H_2S.
W.2292	Oct. 21, 1907	Crude liquids	33	4	37	11	30	41	—	—	—	2·40	9·48	—	·48	1·40	2·08	No H_2S.
W.2291	Oct. 21, 1907	Tank effluent	·4	0	·4	12	28	40	—	—	—	·44	1·24	—	·44	1·20	·36	No H_2S.
W.2494	Mar. 12, 1908	Tank effluent	1·2	1·2	2·4	14	54	68	—	—	—	·54	—	—	—	—	·52	No H_2S.

WORKS F—BROWN PAPER.

W.	Jan. 10, 1907	Crude liquids	105	101	206	66	85	151	—	—	—	8·9	—	—	2·8	—	8·7	No H_2S.
W.	Jan. 10, 1907	Tank effluent	2·0	·8	2·8	39	50	89	—	—	—	2·68	—	—	—	—	2·40	Sl. H_2S.
E. 296	Feb. 19 1908	Tank effluent	2	4	6	24	43	67	—	—	—	1·40	—	—	—	—	1·32	No H_2S.

WORKS G—BROWN PAPER.

W. 104	Jan. 13, 1903	Crude liquids	76	96	172	64	112	176	·19	1·1	7·8	—	20·7	—	—	—	—	—
W. 105	"	Tank effluent	6	22	28	58	100	158	·16	·84	2·7	—	7·5	—	—	—	—	—
W. 995	Jan. 17, 1905	Tank effluent	3·4	8·0	11·4	76	165	241	—	—	—	3·44	—	—	—	—	3·84	No H_2S.
W. 1220	July 6, 1905	Tank effluent	1·6	2·0	3·6	34	89	123	—	—	—	1·20	—	—	—	—	2·50	H_2S.
W. 1820	Nov. 8, 1906	Crude liquids	39	20	59	16	90	106	—	—	—	3·98	11·4	—	—	3·30	3·96	No H_2S.
W. 1821	"	Tank effluent	2·0	4·8	6·8	48	137	185	—	—	—	2·30	7·0	—	—	6·98	2·46	No H_2S.
W. 1877	Dec. 10, 1906	Tank effluent	4·4	11·2	15·6	49	156	205	—	—	—	2·96	—	—	—	—	3·04	No H_2S.
W. 2396	Jan. 2, 1908	Tank effluent	3·2	1·2	4·4	48	131	179	—	—	—	2·46	—	—	—	—	2·02	No H_2S.

WORKS H—BROWN PAPER.

W. 106	Jan. 14, 1903	Crude liquids	135	155	290	172	305	477	·53	·76	23·6	—	39·6	—	—	—	—	—
W. 107	"	Filter effluent	3	2	5	133	171	304	·31	1·17	7·4	—	18·1	—	—	—	—	—
W. 1524	May 6, 1906	Filter effluent	3·0	2·2	5·2	78	146	224	—	—	—	5·84	—	—	—	—	11·34	H_2S.
W. 1971	Feb. 21, 1907	Filter effluent	6·4	11·2	17·6	120	158	278	—	—	—	6·30	—	—	—	—	5·50	No H_2S.

WORKS I—BROWN PAPER.

Organic.

L. 696	Dec. 7, 1904.	Crude liquids	70·5	71·5	142	—	—	—	·80	5·23	—	11·32	33·4	—	6·9	20·8	11·4	H_2S.
L. 697	Dec. 7, 1904.	Tank effluent	5·5	2·0	7·5	—	—	—	·18	1·42	—	2·12	6·0	—	—	—	3·08	H_2S.
L. 1991	Jan. 14, 1907.	Tank effluent	2·0	·4	2·4	96	45	141	—	—	—	6·64	—	—	—	—	6·82	H_2S
L. 2040	Feb. 6, 1907.	Tank effluent	6·4	9·2	15·6	69	42	111	—	—	—	4·98	—	—	—	—	4·16	No H_2S.
L. 2526	Nov. 7, 1907.	Tank effluent	2·8	2·0	4·8	59	60	119	—	—	—	4·60	—	—	—	—	5·96	H_2S.
L. 3188	Nov. 10, 1908.	Tank effluent	2·0	1·2	3·2	46	66	112	—	—	—	2·54	—	—	—	—	2·64	No H_2S.

WORKS J.—BROWN PAPER.

Alb.

W. 111	Jan. 16, 1903	Crude liquids	78	48	126	82	96	178	·35	·90	11·4	—	25·1	—	—	—	—	—
W. 112	"	Tank effluent	7·0	2·0	9·0	76	92	168	·34	·83	7·0	—	14·0	—	—	—	—	—
W. 1896	Jan. 7, 1907	Tank effluent	4·2	3·8	8·0	48	93	141	—	—	—	3·18	—	—	—	—	3·20	H_2S.
W. 2027	April 10, 1907	Tank effluent	3·4	3·2	6·6	47	111	158	—	—	—	2·70	—	—	—	—	2·72	No H_2S.
W. 2664	July 8, 1908	Tank effluent	9·2	8·8	18·0	55	94	149	—	—	—	4·40	—	—	—	—	4·40	No H_2S.
W. 2848	Dec. 17, 1908	Tank effluent	3·2	2·8	6·0	66	141	207	—	—	—	4·38	—	—	—	—	4·42	No H_2S.

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WORKS K—WALL PAPER.

PARTS PER 100,000.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Organic.	Oxygen Absorbed.			In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Alb.		In 15 minutes.	In three minutes.	In four hours.	Alb. Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours.	Oxygen absorbed three minutes.	Odour.
W. 109	Jan. 15, 1903.	Crude liquids - - - - - -	73	112	185	106	199	305	·64	·69	—	16·8	—	27·8	—	—	—	—	—
W. 110	„ „	Tank effluent - - - - - -	1	2	3	46	100	146	·66	·27	—	4·0	—	6·4	—	—	—	—	—
H.	Sept. 17, 1906.	Crude liquids - - - - -	31	17	48	28	58	86	·92	—	·92	—	2·48	7·52	—	—	—	—	—
H.	„ „	Tank effluent - - - - - -	3·0	2·0	5·0	37	97	134	·30	—	·60	—	2·04	6·52	—	—	—	—	—
W. 1749	Sept. 29, 1906.	Tank effluent - - - - - -	9	8	17	42	104	146	·57	·12	1·83	—	3·12	9·60	·10	—	8·52	2·92	No H_2 S.
W. 1806	Nov. 6, 1906.	Crude liquids - - - - - -	56	53	109	58	112	170	—	—	—	—	4·72	14·6	—	2·44	9·96	5·04	No H_2 S.
W. 1807	„ „	Tank effluent - - - - - -	3	10	13	42	127	169	—	—	—	—	2·16	8·04	—	2·12	7·56	2·20	No H_2 S.

WORKS L—PRINTING PAPER.

PARTS PER 100,000.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Nitrates in terms of Nitrogen.	Oxygen Absorbed.		In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Alb.		In three minutes.	In four hours.	Alb. Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours.	Oxyen absorbed three minutes.	Odour.
W. 1491	Mar. 22, 1906	Crude liquids - - - - - - -	3·2	3·0	6·2	124	140	264	—	—	—	3·92	—	—	2·56	—	—	—
W. 1575	May 21, 1906	Third wash from Esparto plus plants as taken - - - - - - -	47	19	66	312	284	596	—	—	—	62·5	138·7	—	54·5	126·4	—	—
		Third wash made acid - - - - - -	172	20	192	208	352	560	—	—	—	25·8	65·4	—	—	—	—	—
		„ „ plus Al.fe. - - - - -	228	76	304	176	344	520	—	—	—	21·7	60·2	—	—	—	—	—
W. 1576	„	Waste water entering tanks - - -	65	41	106	220	204	424	—	—	—	43·9	101·3	—	40·6	91·3	—	—
		„ „ made acid - - - - -	96	16	112	172	280	452	—	—	—	27·3	64·3	—	—	—	—	—
		„ „ plus Al.fe - - - - -	172	60	232	128	272	400	—	—	—	17·0	46·9	—	—	—	—	—
W. 1577	„	Filter effluent - - - - - - -	6·0	8·0	14·0	27	170	197	—	—	—	3·60	—	—	—	—	3·12	No H_2S.
W. 1631	July 2, 1906	Third wash water - - - - - -	59	26	85	322	344	666	—	—	—	62·8	—	—	—	—	—	—
		„ „ made acid - - - -	144	12	156	208	380	588	—	—	—	27·5	—	—	—	—	—	—
		„ „ plus Al.fe - - - -	136	36	172	290	362	652	—	—	—	31·5	—	—	—	—	—	—
W. 1632	„	Filter effluent - - - - - - -	7·2	7·6	14·8	81	172	253	—	—	—	8·64	—	—	—	—	7·52	No H_2S.
W. 1816	July 11, 1906	Crude liquids - - - - - - -	47	42	89	39	118	157	—	—	—	2·30	7·42	—	—	4·88	2·22	No H_2S.
W. 1817	„	Filter effluent - - - - - - -	8	8	16	53	118	171	—	—	—	·96	4·64	—	—	3·20	·98	No H_2S.

WORKS M—BLEACH AND DYE.

PARTS PER 100,000.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Nitrates in terms of Nitrogen.	Oxygen Absorbed.		In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Alb.		In three minutes.	In four hours.	Alb. Ammonia.	Oxygen Absorbed.		Oxygen absorbed three minutes.	Odour.
															In three minutes.	In four hours.		
L. 797	Mar. 8, 1905.	Dye crude liquids	14	7·6	21·6	25	111	136	·65	·14	Nil.	1·34	4·56	·09	·18	2·16	1·64	No H_2S.
L. 798	"	Dye tank effluent	2·8	3·2	6·0	53	92	145	·27	·22	Nil.	1·34	5·82	·19	1·38	5·82	1·36	No H_2S.
L. 799	"	Bleach crude liquids	9·2	2·8	12·0	33	105	138	·02	·09	·40	·72	2·62	·07	·72	2·36	·88	No H_2S.
L. 800	"	Bleach tank effluent	·6	·4	1·0	34	70	104	·04	·14	Nil.	·70	2·16	·11	·72	2·10	·90	No H_2S.
L. 801	"	Bleach filter effluent	4·4	·4	4·8	21	71	92	·08	·21	Nil.	·58	1·38	·08	·58	1·18	·74	No H_2S.
L. 1382	Feb. 28, 1906.	Bleach crude liquids	11·2	1·2	12·4	36	62	98	·10	·07	—	·66	2·42	·06	·30	2·02	·46	No H_2S.
L. 1383	"	Bleach tank effluent	4·8	·8	5·6	42	69	111	·08	·07	·28	·58	2·80	·07	·32	2·60	·60	No H_2S.
L.1384	"	Bleach filter effluent	8·0	1·6	9·6	30	69	99	·07	·12	·24	·40	·94	·04	·24	1·20	·68	No H_2S.
L.	Nov. 7, 1906.	Bleach Crude liquids	16	13	29	28	77	105	—	—	—	·42	2·34	—	—	2·26	·42	No H_2S.
L.	"	Bleach Tank effluent	2·4	·4	2·8	18	84	102	—	—	—	·70	2·76	—	—	2·40	·60	No H_2S.
L.	"	Bleach Filter effluent	4·6	1·6	6·2	20	78	98	—	—	—	·58	1·42	—	—	1·36	·76	No H_2S
L.	"	Dye Crude liquids	42	7	49	77	255	332	—	—	—	—	—	—	—	—	—	No H_2S.
L.	"	Dye Tank effluent	10·5	15·0	25·5	43	103	146	—	—	—	2·28	8·44	—	—	7·98	2.56	No H_2S
L.	"	Bleach and Dye Main effluent	3·6	1·4	5·0	2·5	·75	100	—	—	—	·72	2·54	—	—	1·88	·62	No H_2S.
L. 3155	Oct. 19, 1908.	Bleach Crude liquids	26	42	68	35	149	184	·11	·16	—	1·14	5·02	·12	·80	3·54	1·06	No H_2S.
L. 3156	"	Bleach Tank effluent	3·4	1·3	4·7	32	104	136	·08	·22	—	·84	2·34	·17	·70	1·76	2·74	H_2S.
L. 3157	"	Bleach Filter effluent	1·0	1·5	2·5	27	101	128	·08	·14	Nil.	·30	·94	·10	·28	·82	·46	No H_2S.
L. 3153	Oct. 19th, 1908	Dye crude liquids	16·2	8·8	25·0	51	116	167	·35	·57	—	7·58	17·16	·36	5·86	14·84	7·68	No H_2S.
L. 3154	"	Dye tank effluent	3·4	·6	4·0	34	89	123	·09	·39	—	2·38	8·62	·32	2·28	8·40	2·58	H_2S.
L. 3158	"	Bleach and dye main effluent	1·2	·8	2·0	26	92	118	·07	·18	Nil.	·68	2·4	·16	·58	2·0	1·28	H_2S.
L. 3221	Dec. 3rd, 1908	Bleach crude liquids	20	33	53	19	85	104	·04	·09	—	·44	2·72	—	·44	2·32	·88	No H_2S.
L. 3222	"	Bleach tank effluent	2·6	1·4	4·0	33	84	117	·04	·07	—	·48	2·52	—	·48	2·40	·64	No H_2S.
L. 3223	"	Bleach filter effluent	2·4	·2	2·6	21	82	103	·09	·08	Nil.	·36	1·36	—	·36	1·32	·44	No H_2S.
L. 3219	"	Dye crude liquids	19	20	39	12	81	93	·26	·11	—	1·20	4·80	—	·88	3·08	1·40	No H_2S.
L. 3220	"	Dye tank effluent	3·8	11·6	15·4	41	95	136	·12	·23	—	1·92	8·20	—	1·88	8·36	2·12	No H_2S.

WORKS N.—PRINT.

W. 1812	Nov. 7, 1906	Crude liquids	7·0	2·0	9·0	40	47	87	—	—	—	4·16	14·4	—	3·92	132	4·9	Sl. H_2S.
W. 1813	"	Upper tank effluent	10	1	11	29	43	72	—	—	—	2·52	8·72	—	2·24	7·80	2·60	Sl. H_2S.
W. 2072	May 15, 1907	" " "	1·8	·4	2·2	36	59	95	—	—	—	3·86	—	—	—	—	5·82	H_2S.
W. 2492	Mar. 10, 1908	" " "	4·8	1·2	6·0	26	36	62	—	—	—	2·46	—	—	—	—	2·60	No H_2S.
W. 1359	Dec. 4, 1905	Lower tank effluent	4·8	1·6	6·4	66	59	125	—	—	—	3·32	—	—	—	—	3·46	No H_2S.
W. 2206	Aug. 28, 1907	" " "	2·0	1·6	3·6	37	45	82	—	—	—	2·90	—	—	—	—	3·84	H_2S.
W.2813	Nov. 19, 1908	" " "	15·5	2·0	17·5	46	92	138	—	—	—	4·04	—	—	—	—	4·08	No H_2S.

Mr. Edward Halliwell, F.I.C.

27 Jan., 1909.

PARTS PER 100,000.

WORKS O—PRINT.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Nitrates in terms of Nitrogen.	Oxygen Absorbed.		In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Alb.		In three minutes.	In four hours.	Alb Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours.	Oxygen absorbed in three minutes.	Odour.
L. 3060	Sept. 10, 1908	Crude liquids	—	—	—	—	—	—	—	—	—	·84	—	—	—	—	1·02	No H_2S.
L. 3062	,,	Tank effluent to lodge	—	—	—	—	—	—	—	—	—	·78	—	—	—	—	1·08	No H_2S.
L. 3064 3065	,,	Lodge effluent	—	—	—	—	—	—	—	—	—	1·14	—	—	—	—	1·64	H_2S.
L. 3066 3067	,,	Filter effluent	—	—	—	—	—	—	—	—	—	1·14	—	—	—	—	1·72	H_2S.
L. 3112	Sept. 30, 1908	Crude liquids	3·6	2·0	5·6	39	43	82	·04	·07	—	1·80	8·68	·04	1·56	6·44	1·76	No H_2S.
L. 3114	,,	Tank effluent to lodge	4·8	5·2	10·0	34	46	80	·05	·11	—	1·28	5·48	·08	1·08	4·56	1·18	No H_2S.
L. 3116	,,	Lodge effluent	·8	·8	1·6	28	38	66	·05	·18	—	1·36	4·78	·16	1·26	4·22	1·96	H_2S.
L. 3118	,,	Filter effluent	1·2	·4	1·6	26	40	66	·04	·19	—	1·42	4·84	·12	1·28	4·30	1·90	H_2S.

WORKS P—PRINT AND DYE.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Nitrates in terms of Nitrogen.	Oxygen Absorbed.		In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Alb.		In three minutes.	In four hours.	Alb Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours.	Oxygen absorbed in three minutes.	Odour.
W. 1814	Nov. 7, 1906	Crude liquids	42	7	49	27	118	145	—	—	—	4·20	13·48	—	·76	5·76	3·32	No H_2S.
W. 1815	,,	Filter effluent	1	0	1	45	88	133	—	—	—	1·84	11·0	—	—	—	1·68	No H_2S.
W. 1868	Dec. 5, 1906	Filter effluent	4·0	2·6	6·6	79	26	105	—	—	—	2·12	—	—	—	—	2·24	H_2S.
W. 2703	Aug. 25, 1908	Filter effluent	3·2	0	3·2	19	49	68	—	—	—	1·50	—	—	—	—	1·64	H_2S.
W. 2752	Oct. 1, 1908	Filter effluent	5·2	5·6	10·8	3·8	75	113	—	—	—	2·12	—	—	—	—	2·20	No H_2S.

WORKS Q—PRINT AND DYE.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Nitrates in terms of Nitrogen.	Oxygen Absorbed.		In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Alb.		In three minutes.	In four hours.	Alb Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours.	Oxygen absorbed in three minutes.	Odour.
W. 2151	July 16, 1907	Crude liquids	14	11	25	20	61	81	—	—	—	2·20	6·04	—	·96	2·80	—	—
W. 2153	,,	Tank effluent	7	4	11	24	89	113	—	—	—	2·50	8·16	—	1·60	5·72	—	—
W. 2154	July 17, 1907	Crude liquids	39	50	89	32	103	135	—	—	—	4·30	13·44	—	2·30	6·80	—	—
W. 2155	,,	Tank effluent	9	7	16	34	81	115	—	—	—	1·38	6·60	—	·88	5·40	—	—
W. 2345	Nov. 25, 1907	Tank effluent	2·8	·4	3·2	38	87	125	—	—	—	1·48	—	—	—	—	1·30	No H_2S.
W. 2400	Jan 6, 1908	Tank effluent	·2	2·4	2·6	20	68	88	—	—	—	1·02	—	—	—	—	·50	No H_2S.
W. 2809	Nov. 18, 1908	Tank effluent	1·6	2·0	3·6	42	97	139	—	—	—	·38	—	—	—	—	·32	No H_2S.

WORKS R—BLEACH.

Sample No.	Taken.		Suspended Solids.			Dissolved Solids.			Ammonia.		Nitrates in terms of Nitrogen.	Oxygen Absorbed.		In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Alb.		In three minutes.	In four hours.	Alb Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours.	Oxygen absorbed in three minutes.	Odour.
L. 700	Dec. 7, 1904	Crude liquids	17	34	51	—	—	—	·25	Org. 2·43	—	3·00	14·76	—	2·76	14·48	2·68	No H_2S.
L. 701	,,	Tank effluent	4	10	14	—	—	—	·08	1·24	—	·32	3·56	—	—	—	·48	H_2S.
L. 1393	Mar. 8, 1906	Tank effluent	·8	·8	1·6	22	48	70	—	—	—	·24	—	—	—	—	·24	No H_2S.
L. 2232	June 14, 1907	Tank effluent	2·2	3·6	5·8	34	63	97	—	—	—	·98	—	—	—	—	·98	No H_2S.
L. 2655	Jan. 22, 1908	Tank effluent	2·4	4·4	6·8	44	65	109	—	—	—	·88	—	—	—	—	·86	No H_2S.
L 2918	June 23, 1908	Tank effluent	9·2	4·4	13·6	40	46	86	—	—	—	1 12	—	—	—	—	·78	No H_2S.

WORKS S—BLEACH.

										Alb.								
W. 119	Jan. 23, 1903	Crude liquids	35	55	90	55	63	118	·09	·39	2·9	—	9·4	—	—	—	—	—
W. 120	"	Tank effluent	2·8	1·4	4·2	33	57	90	·09	·14	·98	—	3·3	—	—	—	—	—
W. 1793	Oct. 25, 1906	Tank effluent	3·6	5·6	9·2	40	77	117	—	—	—	1·30	—	—	—	—	1·06	No H_2S.
W. 2174	Aug. 8, 1907	Tank effluent	1·6	3·2	4·8	15	78	93	—	—	—	·68	—	—	—	—	·72	No H_2S.
W. 2846	Dec. 17, 1908	Tank effluent	·8	0	·8	24	53	77	—	—	—	·50	—	—	—	—	·44	No H_2S.

WORKS T—BLEACH.

PARTS PER 100,000.

Sample No.	Taken		Suspended Solids.			Dissolved Solids.			Ammonia.		Alb. Ammonia.	Oxygen Absorbed.		In solution only.			After Incubation.	
			Loss on Ignition.	Ash.	Total.	Loss on Ignition.	Ash.	Total.	Free.	Org.		In three minutes.	In four hours.	Alb. Ammonia.	Oxygen Absorbed. In three minutes.	Oxygen Absorbed. In four hours.	Oxygen absorbed in three minutes.	Odour.
L. 3077	Sept. 16, 1908	Crude liquids	20	30	50	96	60	156	—	—	—	2·84	—	—	—	—	2·60	No H_2S.
L. 3078	"	Tank effluent	2·8	·8	3·6	45	74	119	—	—	—	1·18	—	—	—	—	1·12	No H_2S.
L. 1509	May 21, 1906	Tank effluent	5·8	3·6	9·4	66	87	153	—	—	—	1·62	—	—	—	—	1·56	No H_2S.
L. 1641	Aug. 8, 1906	Tank effluent	2·6	1·6	4·2	38	132	170	—	—	—	2·54	—	—	—	—	4·50	H_2S.
L. 2434	Sept. 23, 1907	Tank effluent	3·8	2·6	6·4	52	112	164	—	—	—	2·60	—	—	—	—	3·74	H_2S.
L. 2703	Feb. 18, 1908	Tank effluent	4·4	·8	5·2	47	72	119	—	—	—	1·12	—	—	—	—	1·24	No H_2S.
WORKS W—BLEACH.																		
L. 698	Dec. 7, 1904	Crude liquids	34	53	87	—	—	—	·53	3·17	—	6·12	27·4	—	5·36	25·5	4·08	No H_2S.
L. 699	"	Tank effluent	23	7	30	—	—	—	·22	·79	—	2·80	13·4	—	—	—	1·84	No H_2S.
L. 2392	Sept. 6, 1907	Kier liquids	33	33	66	440	366	806	—	—	—	13·2	—	—	—	—	14·8	No H_2S.
L. 2393	"	Filter effluent	3·8	3·4	7·2	32	46	78	—	—	—	1·74	—	—	—	—	3·76	H_2S.
L. 2399	Sept. 11, 1907	Kier liquids	61	57	118	389	416	805	—	—	—	12·96	—	—	—	—	13·86	No H_2S.
L. 2401	"	Filter effluent	3·6	1·4	5·0	41	71	112	—	—	—	2·38	—	—	—	—	3·82	H_2S.
L. 3141	Oct. 14, 1908	Crude liquids	49	91	140	87	46	133	—	—	—	1·88	11·46	—	1·76	10·92	1·70	No H_2S.
L. 3142	"	Filter effluent	12·8	14·4	27·2	77	42	119	—	—	—	1·80	8·96	—	1·58	8·88	1·54	No H_2S.
L. 2893	June 3, 1908	Filter effluent	7·6	4·6	12·2	48	61	109	—	—	—	2·96	—	—	—	—	2·26	H_2S.
L. 3020	Aug. 25, 1908	Filter effluent	15·6	14·8	30·4	53	48	101	—	—	—	1·68	—	—	—	—	1·68	No H_2S.
E. 411	Oct. 5, 1908	Filter effluent	7·6	10·0	17·6	116	136	252	—	—	—	4·66	14·88	—	—	—	5·28	H S.
L. 3244	Dec. 11, 1908	Filter effluent	3·6	6·0	9·6	103	79	182	—	—	—	2·44	—	—	—	—	1·92	No H_2S.
WORKS V—DYE.																		
L. 716	Dec. 14, 1904	Aniline Crude liquids	37	215	252	—	—	—	·65	1·03	—	17·5	64·6	—	—	—	14·4	No H_2S.
L. 717	"	Aniline Filter effluent	1	2	3	—	—	—	·06	·36	—	27·9	35·0	—	—	—	25·4	H_2S.
L. 1164	Sept. 28, 1905	Aniline Crude liquids	14	2	16	206	186	392	·18	—	·20	5·40	29·52	—	4·08	31·16	6·20	H_2S.
L. 1165	"	Aniline Tank effluent	6·0	2·0	8·0	322	148	470	·20	—	·17	5·32	30·7	—	4·52	30·28	5·40	H_2S.
L. 1166	"	Aniline Filter effluent	17	3	20	328	152	480	·18	—	·14	5.96	25·48	—	4·40	25·2	6·56	H_2S.
L. 1242	Dec. 4, 1905	Aniline Filter effluent	6·4	3·8	10·2	309	114	423	—	—	—	6·48	—	—	—	—	9·04	H_2S.
L. 1465	Apr. 23, 1906	Aniline Filter effluent	·8	·0	·8	79	67	146	—	—	—	1·78	—	—	—	—	2·62	H_2S.
L. 1702	Sept. 15, 1906	Aniline Filter effluent	2·4	2·4	4·8	113	151	264	—	—	—	7·14	—	—	—	—	6·84	No H_2S.
L. 718	Dec. 14, 1904	Indigo Crude liquids	7	19	26	—	—	—	·08	—	1·16	2·80	13·28	—	1·32	5·36	3·20	No H_2S.
L. 719	"	Indigo Tank effluent	1	1	2	—	—	—	·10	—	·50	1·40	5·0	—	—	—	1·24	No H_2S.
L. 3125	Oct. 2, 1908	Aniline and Indigo Tank effluent	3·4	1·4	4·8	107	117	224	—	—	—	3·0	—	—	—	—	3·12	No H_2S.
L. 3208	Nov. 25, 1908	Aniline and Indigo Tank effluent	2·4	·4	2·8	115	98	213	—	—	—	1·58	—	—	—	—	1·70	No H_2S.

Mr. Edward Halliwell, F.I.C.

27 Jan., 1909.

Mr. Edward Halliwell, F.I.C.

27 Jan., 1909.

RIVER RIBBLE AT WALTON BRIDGE.

PARTS PER 100,000.

Sample No.	Taken.		Chlorides in terms of Chlorine.	Ammonia.		Nitrites in terms of Nitrogen.	Oxygen Abs'rbed		After Incubation.			Dissolved Oxygen in c.c. per litre.	
				Free.	Alb.		In three minutes.	In four hours.	Oxygen absorbed in 3 mins.	Nitrates in terms of Nitrogen.	Odour.	When taken.	After 24 hours incubation.
W.L. 34	21/7/08	Extreme Oxygen Absorptions	1·8	·039	·025	·065	·1	·43	·10	·18	No H_2S	6·3	5·9
W.L. 44	14/8/08		4·9	·025	·025	·18	·08	·31	·08	·20	No H_2S	6·7	5·2
		Average of 10 monthly samples	2·3	·036	·017	·10	·10	·33	·086	·11	No H_2S	7·7	6·5

RIVER RIBBLE AT L. & Y. RAILWAY BRIDGE; SOUTH BANK.

PARTS PER 100,000.

W.L. 60	30/11/08	Extreme Oxygen Absorptions	2·0	·09	·025	·16	·11	·35	·05	·16	No H_2S	8·01	6·72
W.L. 21	12/3/08		2·4	·085	·022	·12	·14	·42	·12	·128	No H_2S	7·7	5·2
		Average of 10 monthly samples	3·5	·12	·027	·148	·162	·46	·134	·147	No H_2S	6·75	5·11

RIVER RIBBLE AT L. & Y. RAILWAY BRIDGE; NORTH BANK.

PARTS PER 100,000.

W.L. 53	24/9/08	Extreme Oxygen Absorptions	2·0	·03	·016	·065	·12	36	·11	·07	No H_2S	6·66	6·13
W.L. 22	12/3/08		1·8	.018	·015	·075	·11	·30	·09	·08	No H S	7.80	6·25
		Average of 9 monthly samples	2·1	·04	·015	·09	·096	·34	·09	·10	No H_2S	7·92	6·80

RIVER DARWEN JUST ABOVE JUNCTION WITH RIVER RIBBLE.

PARTS PER 100,000.

W.L. 66	28/12/08	Extreme Oxygen Absorptions	4·6	·31	·04	·22	·24	·58	·30	·28	No H_2S	8·31	5·90
W.L.	24/6/08		7 6	·52	·10	Nil.	·42	1·26	·38	Nil.	No H_2S	2·60	·28
		Average of 10 monthly samples	5·0	·29	·06	·19	·29	·85	·24	·16	No H_2S	5·34	1·82

Dr. W. WILLIAMS, Medical Officer of Health to the Glamorgan County Council; and Colonel LEWIS, Chairman of the Sanitary Committee of the Glamorgan County Council, called in; and Examined.

Dr. W. Williams and Col. Lewis.

27 Jan., 1909.

27967. (*Sir William Ramsay*) (*in the chair*). May I just ask, Dr. Williams, you are Medical Officer of Health of the Glamorgan County Council ?—Yes.

27968. Have you been acting in that capacity since 1892 ?—I was appointed in December, 1892.

27969. Before that you were acting as Assistant and Deputy Medical Officer of Health in Shropshire ?—That is so.

27970. The estimated population, including the Boroughs of Cardiff, Swansea and Merthyr is about 1,000,000 people ?—About 1,000,000.

27971. The county on the whole consists of a number of valleys ?—A number of valleys and vales. Vales to the south and valleys to the north; the latter being long, narrow, deep and crooked.

27972. You have nothing in the shape of River Boards ?—We have no River Boards at all; we used to have a joint committee once some years ago, consisting of certain members of the Glamorgan and Monmouth County Councils.

27973. Then a large part of the population I suppose lives in Cardiff and Swansea ?—No, the population of Cardiff is about 180,000, and the population of Swansea about 100,000, and a very large number of the population live in the valleys, which are really long channels stretching for miles from north to south. There is one district there, the Rhondda, with a population of 140,000, or thereabout.

27974. Roughly speaking, you put the population of Swansea and Cardiff at about 280,000 ?—That is it, roughly speaking.

27975. Are there any other large towns besides Cardiff and Swansea on the coast ?—Yes, there is another fairly large town on the coast, namely, Barry, with a population of 30,000.

27976. Like other parts of the world you suffer under the dictum that pollution by coal washing is not pollution under the Act ?—Yes, that is so.

27977. And you would desire to see coal washing brought under the Act ?—Yes, decidedly; we feel that we are powerless almost.

27978. How much has been done in the way of settling coal dust washed down the rivers from coal washing ?—To prevent it ?

27979. To prevent it ?—Very little really; there are some companies who have put up settling tanks; about twelve to eighteen, that is all.

27980. Is that a small proportion ?—Yes, a very small proportion, because we have a very large number of collieries, large and small.

27981. And do they not find that it pays to settle their small coal ?—I suppose those that have put them up find that it pays, but it is a difficult matter to try and persuade the others to put them up. They feel we have not got the power, and they will not go to the initial expense.

27982. And the example of those who have done it is not sufficient to persuade others who have not done it to join ?—No, I should say not. I remember we took proceedings years ago against a certain colliery company, and the action was dismissed with costs. It is not supposed to be pollution under the Act; it is discolouration.

27983. It is not supposed to be pollution under the Act. Have you any experience of the effluent from the settling tanks where settling of small coal is practised; is the effluent satisfactory ?—Well, I have not analysed any at all, not up to now.

27984. But as regards the appearance ?—Oh, in some places, as regards the appearance——

27985. It is quite clear ?—Well, sometimes it is quite clear; not as a rule.

27986. Then you would desire to see this pollution by small coal brought under the Act ?—Yes.

27987. As regards the tin-plate works, you say the pollution is much less than was the case years ago ?—That is so, undoubtedly.

27988. They add scrap-iron to the pickle, neutralise it and evaporate, and recover sulphate of iron ?—Yes, that is it; they have put up copperas plant in nearly all the works.

27989. Do you know that it pays ?—Yes, I know now that it does pay; I have it on good authority that it does pay, but we were told years ago that it did not pay, but the price is fairly high at present.

27990. Do you know what becomes of the sulphate of iron ?—Yes, it is used for making a germicide for disinfecting purposes, and to make paint and manure. I am told they can make it for about 10s. a ton, and sell it at somewhere between 12s. and 21s.

27991. In the case where they do not neutralise the acid completely with iron and then evaporate, they filter sometimes through lime-stone, do they not ?—Not the pickling, but the swillings they do.

27992. The swillings ?—Yes, but there is great difficulty to get them to do much, and to renew the limestone as often as they ought to do it, because they get covered by yellow oxide of iron, and then there is an end of the process.

27993. Is there any value in the yellow oxide of iron ?—I do not think there is any value in it in any case we know; not in many of them; they use it in paint, but I do not think they make any use of it at our works.

27994. What is done with it; is it simply bedded or piled in stacks ?—It is simply piled.

27995. None ot the waters of the Glamorgan rivers are used for drinking purposes after sewage has entereed them, I see you say here ?—Not by human beings.

27996. Then we can consider the pollution as derived from sewage, from small coal, and from tin plate works ?—Those are the sources of pollution.

27997. Is there any pollution from the large copper works at Swansea ?—Well, there may be, but Swansea is not in the administrative county; I have no knowledge of the works inside the borough.

27998. Would you wish to borrow Sections 14 and 15 of the Mersey and Irwell Joint Committee Act, namely, as regards the word "person," or as regards the word "stream," or as regards the words "solid matter"? Are you under any disability by not having any of these terms enforced ? I see you quote the Mersey and Irwell Joint Committee Act, 1892; would you wish that the terms of this Act should be made applicable to your district ? What is your reason for quoting those terms ?—I thought that by this Act we could get the small coal included.

27999. In the word "stream" ?—Stream. Of course we have canals also.

28000. Have you canals ?—Oh, yes, a good many, and a good deal of pollution; they are greatly polluted at times.

28001. So you wish "streams" were defined to include canals ?—Yes, canals should be included.

28002. Are you also troubled with mine water ? We have been informed, for example, that water pumped from a mine is very often highly ferruginous, and deposits ochre ?—Yes, there are some that do so,

28003. That occurs also in your district ?—(*Colonel Lewis.*) I do not think you know them; I could give them.

28004. Very well, we will reserve that question. You have at present a sanitary inspector ?—(*Dr. Williams.*) Yes, Sir.

28005. In order to visit the works of sanitary authorities, colliery, tinplate and other works, and to take samples for analysis, and to attend court ?—Yes, we have had him for some years.

28006. But in many cases he is unable to stop the nuisance, because he cannot threaten proceedings ?—That is it. We can deal pretty well with the tinplate works, but not with the collieries, except for what visit will do.

28007. The operations that go on in tinplate work are first of all to clean the iron plate ?—Yes.

28008. By means of acid and bran ?—Yes, by acid and bran. There is some bran used; I should have mentioned that.

28009. And then the pickle consists of sulphate of iron with excess of sulphuric acid ?—That is it.

28010. It is neutralised, and then boiled down and sold ?—It is neutralised by the addition of scrap iron, and evaporated, re-evaporated and allowed to crystallize.

28011. Does any pollution result from the bran ?—No, not so far as I am aware.

28012. It is not allowed to run into the river ?—No. We have never been troubled with that.

28013. Is there lime-stone in the district ?—Oh, plenty in the southern parts of the county. Lime-stone is plentiful and it is easily got.

28014. Does the lime-stone require much preparation before it is used, or could it be used in fairly large lumps ?—In small lumps. It ought to be broken up to get as much surface as possible. We find some difficulty in persuading the owners to put it down.

28015. Is it used in that form on filters, or is it piled in heaps ?—Piled in heaps generally.

28016. You find that on the whole the proprietors of works, the manufacturers, are willing enough to purify their liquors ?—The tinplate manufacturers ?

28017. The tinplate manufacturers, yes ?—Yes, they are willing now at any rate to deal with the pickle, but there is certainly difficulty to get them to do anything with the swilling fluid; it is so large in volume.

28018. You find that lately, during the last few years, they have done more swilling than they had before ?—Oh, I think so, certainly. I think copperas is fetching a better price; very likely. Of course, there are some of the works on tidal waters.

28019. You find a reluctance to purify the effluent ?—Oh, certainly, the swilling effluent.

28020. They simply turn it into the tidal waters ?—That is it.

28021. Do they cause much accumulation on the shore ?—Yes.

28022. Do they interfere with the fishing on the shore ?—I should say so. I do not know much about fishing myself.

28023. There are fish ?—Not any shell fish; there are oyster plantations about seven miles away from Swansea, lower down, near Oystermouth.

28024. They are not interfered with ?—No, I do not think so; not in the least.

28025. From your figures in your proof, I should fancy that something like 2,000 tons of crystallised sulphate of iron will be produced per week ?—About 900 tons of sulphuric acid is used weekly.

28026. That is somewhere between 1,500 and 2,000 tons of sulphate of iron, I think ?—Yes, about that. I have had it from several sources, the amount of crude sulphuric acid used per week is about 900 tons.

28027. Are there many works which do not convert the waste pickle into copperas ?—Yes. There are not many; there are a few, especially on tidal rivers. What is done in some of these is, they sell the pickle to a person or persons for a sum and they make as much copperas out of it as they can. That is what is done in some places, so that the owners of the works themselves do not trouble about it. In some places, mostly in the borough of Swansea, that would be the case, I think.

28028. It is a product that will not stand carriage. Of course, it is not sufficiently valuable to make it possible to carry it many miles ?—Sulphate of iron ?

28029. No, I mean waste pickle ?—No, it is not; it must be a difficult matter.

28030. It must be worked on the spot ?—Yes, or very near the spot. It has to be pumped.

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28031. Do you think it would be reasonable to insist on every works using up its waste pickle in the form of copperas ?—Yes, I do.

28032. And on the whole it would be to their advantage ?—I think so.

28033. You would like also that facilities should be given for taking samples and making inspections of the works. Would you make it compulsory that the manufacturers should allow the visits of inspectors ?—They do allow them, as a matter of fact, but they need not. We have never had any trouble with the tinplate manufacturers, but we have no authority really to be on the premises.

28034. It is hardly worth while raising the question you think ; you get admission ?—Oh, we do into the tinplate works, but with the others to be established later on I think there might be difficulty.

28035. Then as regards the swilling fluid, you would make its purification voluntary ; that is to say, you would take into consideration the situation of the works and the various points connected with the works ?—Yes. I think, if the water of a river where the works are situated is made use of lower down for drinking purposes by animals, something ought to be done.

28036. Are there any fish in the river ?—Oh, yes. Colonel Lewis knows about that better than I do, but there is one river in particular, a fairly good fishing river, and on this river there is a very important tinplate works about twelve miles from the sea, and we are told sometimes that they put some of the pickle in on a Saturday afternoon all of a heap and kill the fish. I have no evidence ; I cannot prove this.

28037. Then you would like the regulation to be such that they would deliver the pickle, if they did turn it into the rivers, in small quantities at a time ?—Certainly, The swilling fluid ; they do not put in the pickle as a rule.

28038. I beg pardon ; the swilling fluid. Have they tanks to contain this swilling fluid ?—No, only sumps, not tanks. They pass it over limestone chippings.

28039. Do you think tanks should be provided, so as to make it possible to bring about a regular flow ?—It is difficult to say, because the volume of water that passes along is sometimes very, very large. We have not many of these works on rivers that are fishing rivers. I think it would be only about two. (*Colonel Lewis.*) They are not fishing rivers now.

28040. Have your rivers been fishing rivers previously ?—I suppose some of the best in the United Kingdom.

28041. And they are now of no use ?—No.

28042. I suppose the effect of the swilling liquid on the lime would not be to produce an injurious effluent ; it would deposit most of the iron ?—(*Dr. Williams.*) It would deposit most of the iron.

28043. And most of the sulphuric acid as sulphate of lime ?—Only the sulphuric acid is difficult to bring down, is it not ?

28044. Yes, but if it were passed through a sufficient amount of limestone, sulphuric acid would be retained too ?—Yes, no doubt.

28045. And there is no harm in the rivers containing sulphate of lime ?—Not to a small extent, as far as I know.

28046. No, I do not think there is. You give figures to show the magnitude of the coal mining industry in South Wales ?—Yes, at the end of the year 1907. There is a large number of people employed in the coal mining industry.

28047. Very large ?—Yes, very large. I should think now about 140,000 people, and somewhere between 15,000 and 20,000 employed at the various tinplate works. I am told so.

28048. Then very few of the collieries have settling tanks or ponds ?—Very few ; I think they are increasing in number now. I know there are preparations for putting up several going on.

28049. Have you ever tried to persuade the proprietors who do not use settling tanks that they are losing money by not doing it ?—Well, we have spoken to them, but there has been no united effort.

28050. You cannot do that, but are they not to be persuaded that they are losing money by not doing it ? I may mention we have had evidence to show that in Yorkshire, for example, and in Lanarkshire, there is a very great deal of money made by saving the small coal ?—I believe there is in our county, but where the small coal is made use of and made into coke, and so on, there is a tendency to put up washing machines, because there were very few there six years ago. There are several now.

28051. You mention the plan of using the water over and over again ?—Yes.

28052. Has that been applied in your district ?—It has been applied, yes.

28053. But I think on a small scale ?—Only on a small scale.

28054. Because again we have evidence that in Lanarkshire they use the water over and over again ?—Yes, they do use it with us over and over again, but not so often as I should like to see it done.

28055. Of course the best argument to induce manufacturers and colliery owners to carry out this is the appeal to their pockets ?—Certainly.

28056. And if one could persuade them that in other parts of the country considerable amounts of money were being gained by saving the small coal they would do it ; they would require very little persuasion ?—Yes, some would do it I have no doubt.

28057. Then you mention that a case has been tried, and naturally given against the Glamorgan County Council ?—Yes, it was tried some years ago.

28058. Then you have also by-products works ?—Yes, we have three.

28059. Only three ?—Only three now, and another is about to be put up.

28060. They are likely to increase very largely, are they not ?—I think they are, yes.

28061. The waste liquor I presume comes from the ammonia condensing plant ? The gas is scrubbed, is it not, in water, so as to produce ammonia solution which is then distilled with lime to get off the ammonia ?—To get off the ammonia.

28062 And then it is the residue remaining in the stills that is polluting, containing, as it does, tar and lime and salts of various kinds ?—Yes, lime and salts of various kinds, but at our three works there is made coal gas, sulphate of ammonia, tar, pitch and anthracite oil, but that is the exception.

28063. No cyanide compounds ?—No, none at all. I made a point of asking that. The coal is not of such a quality as to give rise to much cyanide ; so I am told.

28064. Have you ever analysed the liquor, or had the liquor analysed ?—No, never ; every time we go to these works we have to get permission.

28065. Are they very chary in giving permission ?—Well, no, they have never refused, but they are very careful. I should like to have power to take samples, but you cannot ask for power to enter the works and to take samples at the same time, so I have been entering the works pretty frequently of late. They are very kind in explaining everything, and all that.

28066. They do not treat you disagreeably ?—Oh, not at all ; not the slightest. In one of the works the effluent, or the waste that enters the river, is filtered through sand and lime.

28067. Does that purify it ?—Well, I suppose they think so. I do not know myself. And in the other all the waste goes down into a disused pit.

28068. And disappears ?—And disappears. There is no pollution of any stream there, and in the third, I believe, the waste gets access—we cannot find the way it goes—into the stream or ditches about.

28069. You cannot say that there are not cyanide compounds ever discharged, but still you have not tested for them ?—No, we do not know. Next time I go to the works I intend to ask for permission to take samples, These works have only been established a few years. They are in working order now, and I think I might ask for permission to analyse samples.

28070. You wish to investigate the processes more thoroughly than you have been able to do ?—Well, I have been pretty thoroughly into them now.

28071. Are there any facilities for discharging such liquors into the common sewers, so that they might be treated along with the domestic sewage ?—In these by-product works ?

28072. In the by-product works ?—Not for any.

28073. Would it be possible to connect them with the sewers ?—It is possible.

28074. Would it be desirable ?—No ; not desirable, I should think.

28075. Probably it would interfere with the usual process of bacterial filtration ?—It would be possible, but the question of levels would come in in one ; in the other it could be done, but I do not think it is desirable at all.

28076. Are the ordinary sewage discharges from the neighbourhood treated—the domestic sewage ?—Yes, from the neighbourhood of one of these by-product works the sewage is treated on a sewage farm ; from the other it is treated in bacterial tanks, and from the third it goes into the sea.

28077. Are the processes fairly satisfactory in those cases ?—Yes, they are quite ; they give very good effluents.

28078. So that it would not be advisable to interfere with those processes ?—I think not.

28079. By running the spent liquor from the ammonia stills into the sewers ?—No, certainly not.

28080. What do you precisely mean by a few offensive trades ; tanneries ?—Yes, tanneries and fellmongers' works.

28081. You do not think that they deserve consideration ; they are too few in number ?—Well, we have not had trouble with them. They are very few in number.

28082. And small in size ?—And small in size too.

28083. Is much brewing carried out in your part of the world ?—Well, not in the administrative county ; nearer the towns. There are one or two biggish ones in the administrative county.

28084. And they generally discharge their waste into the sewers ?—I have got two in my mind now in the Rhondda ; the waste goes into the sewer.

28085. Does that give any trouble with the subsequent treatment, does it interfere with the ordinary treatment of sewage ?—No, it does not, because the sewage from the bigger of the two works goes into the sea. It is a combined drainage area, a sewerage area discharging into the Bristol Channel.

28086. And in the other cases I suppose it gets treated along with the ordinary sewage ?—Along with the ordinary sewage.

28087. Without trouble. It does not bear a very large proportion in bulk to the ordinary sewage ?—No, a very small proportion really.

28088. You would suggest that the chemist attached to the by-product works should pronounce what remedy should be applied ?—I think they would be the best judges. I will get to know from them by and by, but they would be the best judges what the remedy would be really.

28089. You think on the whole the condition of the rivers in the county is improving ?—On the whole, the condition of the rivers in the county is improving, especially as regards sewage and pollution from tinplate works ; but for the small coal there is not much to be said.

28090. You think that the periodical inspection is producing very valuable results ?—I think it is doing good.

28091. Do they know that you have no real power ?—Yes, they know perfectly well.

28092. But still, in spite of that ?—In spite of that, they are very kind.

28093. Is anything ever delayed owing to the idea that there will be legislation before long ?—Anything ever delayed ?

28094. Yes, do you find manufacturers are delaying to purify their waste liquors from taking place under the notion that before long fresh legislation will be introduced ?—Yes, I think they are aware that in all probability fresh legislation will be introduced. I think so, from what I have been told.

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28095. But you do not find that that prevents them putting up improvements ?—I think you want to say it does rather, because it is difficult to tell them what to do. "Tell us what we should do, and we will do it," some of them say. That is a very difficult matter.

28096. Then as regards the alteration of the law, you think that the wash water from the coal washing machines should come under the Act, so as to be considered as a pollution ?—Yes.

28097. And that the Mersey and Irwell provisions suffice for the rest of the impure effluents ?—It appears to me that is the only way to get the rivers anything like clear.

28098. (*Mr. Tatton.*) In this case that you had for pollution from the coal washing, in which it was brought in as an innocuous discolouration, do you remember what class of effluent that was. Was it very bad ; was there much suspended matter in it, do you recollect ?—I had only just been appointed then. I know there is a great deal of small coal entering the river, and it is the same to-day. I do not remember anything about the analyses of the effluent.

28099. Have you had lately any analysis of the effluent ?—No, we have not.

28100. Have you taken samples of it at all ?—No, we have not ; not of that.

28101. Is there much deposit ?—There is a good deal of deposit before a flood.

28102. On the banks ?—In the bed of the river. Here there is a big wall, a high wall abutting on the river quite near, and there is a good deal of deposit before floods in dry weather, and it is all cleared away with a big flood. I think that was one of the reasons why it went against us was because it did not hinder the flow of the river at all.

28103. (*Chairman.*) Are the river banks not usually black ?—Oh, yes, some of them very black.

28104. Then when the flood comes, do they turn white again ?—Oh, no, they are black always, but sometimes worse than others.

28105. (*Mr. Tatton.*) Do you think now that you would not be able to prove a case in court ?—If we went to court again ?

28106. If you went to court again ?—I feel sure we could not.

28107. You would not be able to get a sample ?—Oh, yes, we could get a sample.

28108. If you had a sample, would there be a deposit such as you have in that bottle for instance ?—Oh, yes, there would.

28109. In an 8-inch bottle, would there be half an inch ?—Yes, quite, I should say.

28110. I think you would get over the innocuous discolouration ?—Well, there is a great deal there.

28111. (*Chairman.*) Could you point to any damage done by this coal dust in the rivers, except the destruction of fish ?—No, I do not think you can. I do not know if you can as to cattle ; I have been told that with a tinplate effluent you can, but that is another thing entirely. But with the coal dust I do not know that you can. I do not know myself.

28112. It is very largely an æsthetic question ?—It makes the rivers black, and if the rivers are black they are supposed to smell. The Taff, a river that passes through Cardiff, is very, very black. There is no sewage in it ; it is black. It does not smell, but the people will not believe it that they do smell. There is a great deal in that.

28113. There is always the destruction of fish ; the fish cannot live in such black rivers ?—No.

28114. Are they actually killed, do you know ?—Well, I leave that to Colonel Lewis. (*Colonel Lewis.*) Yes. Sir, the Taff was an excellent trout river before they begun to work. I am going back to my father's evidence when I was quite a boy. Trout fishing was very good

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indeed in the Taff, and excellent trout were caught. There is scarcely a trout to be seen in the whole of the river now. This deposit comes down, and it sinks in. I have given evidence before a great many Commissions that have been down from up to twenty years ago, and I have produced bottles showing the black deposit on the bed of the river. It is always there.

28115. Of course, it must interfere with the fish food. I presume green growths do not grow ?—It is an extraordinary thing that coarse fish can live in it, but trout cannot live in it, neither trout nor salmon.

28116. Do they get feeding ?—They get feeding. Down below there are certain weirs all down the river for works of all sorts. There are large weirs constructed ; that forms a sort of settling place above these weirs where all this goes. Well, below Llandaff weir, or after Llandaff weir, it is, and down below there there are a lot of coarse fish, and there are a certain number of coarse fish, eels especially, above. The water has been deposited higher up in pools, and settled there, and just towards the end it is fairly clear.

28117. And you do get green growths ?—No, I do not think there is any growth at all in the river ; no growth of any sort, I should say.

28118. I suppose we must take it that the ultimate food of the fish comes from green growth ?—Yes, and the fly ; the larva. When the fly is deposited on which the fish feed, it is on the stones, and it comes up and forms the fly ; the larva is on the stone that forms the fly which the fish feed on. This black stuff settling prevents any larva at all from existing ; there is no food.

28119. So I think it will be pointed out that the rivers are damaged so far as fish are concerned in that way ?—Yes, Sir ; I have never taken up the question of fish on account of the industry of the country. You have to sacrifice something for the industry of the country.

28120. Well, that is only a question for you ?—Well, yes, Sir, you are right. Thank you.

28121. Mr. Willis has pointed out to me that in your proof you discuss the question of some sort of standard ?—(*Dr. Williams.*) Yes.

28122. Do you find that that standard can be enforced, or is it only for your private guidance ?—For our private guidance. It can be attained at any rate.

28123. Do you find that such a standard is sufficient to prevent injury to the stream ?—Well, it can be easily attained. I have figures here to show that the sulphate of iron can be reduced to less than 100 parts per 100,000.

28124. Does it prevent injury if it is attained ? Would you be satisfied with such standards for preventing injury ?—Well, we have been satisfied. We have looked upon them as standards, but we have nothing to go by.

28125. Do you think that a more rigorous standard could be set up with advantage ?—We often get better results than 10 and 100 of acid and sulphate of iron respectively per 100,000 parts. I have figures before me now extending over a period of a year. We have adopted those, for we have found out by experience that they can be easily attained.

28126. Would fish live in a river which complied with your standard ?—I am not quite sure about that. I have seventeen sets of figures here giving the acidity, and with the exception of four they are well under 10.

28127. The reason you put this standard is because it is easy to get down to it ?—It is quite a simple matter to get below 10 with acids. I find that with experience. I have here an analysis of 17, showing free sulphuric acid, and with the exception of 4 they are all well under 10, and of course tinplate works. Then they were telling me at the works that the canal lower down, where the effluent was discharged, there were trout to be found, but then a good deal would depend upon the dilution after entering the stream, and we estimate that in every instance.

28128. No doubt such a dilution would make those standards sufficient ?—I should think so.

28129. Have you got any figures to support the statement that the material which is collected in these ponds and tanks, viz., the fine particles of coal, is an excellent fuel, and is suitable for burning under boilers for steam raising purposes. You go on to say, "Therefore, the initial cost of the erection of the necessary plant would soon be recouped by the valuable material recovered."—I have no figures.

28130. You have no figures ?—No.

28131. Do manufacturers admit that ?—Yes, they do.

28132. That the cost would be recouped, I mean ?—Yes, they admit that at once.

28133. (*Colonel Harding.*) Then why do they not carry out the work, if they admit it would be a benefit to them. Why do they not carry it out ?—I suppose the initial cost has something to do with it. There is a tendency to put up washers now by some of the more enterprising companies.

28134. Are there any cases in your district where the wash waters are delivered without settlement into the river, or into tidal waters ?—No, not without some treatment.

28135. There is some settlement ?—Much settlement.

28136. What kind of results are obtained ? Have you had any samples taken ? You told us just now that a large quantity of coal goes forward ; do you know what quantity of suspended matter passes with its effluents to the stream ?—No, I cannot say that.

28137. You are satisfied that a large amount does go ?—Oh, a large amount does go ; there is no doubt about that.

28138. And you yourselves are satisfied that it would be advantageous to the colliery proprietors to withdraw this ?—Yes, I feel sure it would be.

28139. Have you ever had an opportunity of acquainting yourself with what has been done in Yorkshire ?—No, I never have, Sir.

28140. I suggest it would be of advantage to you if you communicated with the chief officer of the West Riding Rivers Board, because works have been carried out there ?—Yes, I know him quite well.

28141. And your excellent suggestion about using the water over and over again is applied there largely ?—Yes.

28142. Is that applied in your district at all anywhere ; do they use the water again and again ?—Yes, to a certain extent ; but not to the extent it ought to be, I think.

28143. There are certain passages in a document which is marked "confidential," which probably you could get from Dr. Wilson ?—Yes, I suppose so. I have got some from him.

28144. He says : "It is gratifying to find that the measures of purification adopted by colliery proprietors have resulted in great saving to them " ?—Yes.

28145. And then he points out further that in re-using the water the effluent is reduced to about one-tenth or even one-eleventh of what it would otherwise be, and that in twenty-one instances where 5,500 tons of coal are washed daily, no water from the coal washing processes escapes to the stream, because the one-tenth or one-eleventh part is sufficiently purified to enable them to use this in their boilers ?—Quite so.

28146. So that in fact there is no effluent at all ?—I am quite convinced it can be done, but the difficulty is to get them to do it.

28147. Well, possibly if they knew this had been carried out satisfactorily elsewhere, it would be of great utility to you, and, therefore, I suggest to you that you might with advantage communicate with Dr. Wilson at Wakefield, who probably would give you this document, and the information that is required ?—Thanks ; I will do so, certainly.

28148. Because it does seem inexcusable to turn large quantities of fine coal out into the streams, or even into tidal waters. You have not said very much about pollution by gas liquors or the ammoniacal waters ?—

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Well, we have not been troubled with them; we were some years ago in one or two instances.

28149. It is not a serious matter in your case ?—No; you see, they sell the ammoniacal liquor generally. I only remember two instances where we had some trouble.

28150. In regard to the pickle, in your case it is treated so as to draw from it the copperas ?—Not in every case; very nearly.

28151. Are you not able to insist upon that? You see, it is quite practicable; it is done by most manufacturers ?—Oh, yes.

28152. That is proof that it is reasonable and practicable ?—Oh, it is reasonable and practicable, and it pays.

28153. If it is reasonable and practicable, why cannot you insist upon that being done ?—There are very few works indeed not making copperas now; there used to be a large number. They are improving all the time in that respect.

28154. Then speaking generally, you are able to tell us that it is simply the final washing waters ?—The swilling water.

28155. And do you know what, on the average, is the acidity of those ?—Yes, I have here some figures of the acidity of the swilling fluid.

28156. What effect does it produce on the stream? You say it does not kill fish life ?—Well, if you put it in all at once, as they generally do, I think it does.

28157. You have raised a point of very considerable interest. In one large town in the North of England very serious inconvenience arises through their flushing out large tanks containing ferrous sulphate, and this was flushed into the sewers and caused great inconvenience at the sewage disposal works ?—Quite so.

28158. And they made arrangements with the manufacturer to have a storage tank in his yard, from which a continuous flow went on during the twenty-four hours at an even quantity per hour. Would it not be quite easy in the case you mention to get the people to put up a storage tank, so as to enable them to cause the flow to be continuous, and, therefore, small in volume, instead of rushing it in all at once? I notice that Colonel Lewis shakes his head.—(*Colonel Lewis.*) I might tell you, very often it comes on a Saturday afternoon, when there has been the whole of the swillings for the week. The gentlemen who have been working at the works are in a hurry to get home, and, therefore, they want to pull up a trap and let it all go at once. That is why on Saturdays, as a rule, the swillings are worse than any other day. They wish to get away, and the workmen—I do not know why it is done—let all the swillings go.

28159. But I am afraid it is a necessity of the trade that these swillings should be let off all at once in that way, but the suggestion is that there should be between these tanks and the final outfall an intermediate storage? —Yes, Sir, you are perfectly right, and I wish that could be done. I wish the power was given to us in this noble Act, the Rivers Pollution Act, to carry that out. If we could carry that out it would be done, but we have no power under that Act to carry it out.

28160. But it is so reasonable and inexpensive ?—Yes, it is.

28161. That I should think it exceedingly likely, if you pointed out to the manufacturer that great good would result from their doing this, that they would do it, because it is simply a question of storage ?—I have been trying for twenty years to do it. For twenty years I have been at them and asked them to do it. For over twenty years, or rather more, I have persuaded them to allow me to visit the works, and asked them to do all this, but there is no result at all in a great number of these works.

28162. Have you asked them to stop letting off the tanks with a rush, or have you asked them to introduce this intermediate storage tank ?—I have asked them to make tanks, settling tanks, so as to let it run through. They have in a great many of these works large cinder tips. "Now," I said, "it would be no expense to you at all if you were to make a large sort of hole through these cinder tips, and let your swilling water run off as it comes away through these cinders and scrap iron." I daresay you know what all these cinder heaps are made of, and that would simply purify the water in a great measure. And they said, "Oh, yes, yes, yes." Well, I have gone down in the path by me. I have gone two or three days after, and I have seen the whole of the water the colour of a London fog.

28163. You are not complimentary to London. Then you have not found that in any case you have been able to induce the tinplate people to put in a storage tank ?—Some of them have, and some of them have taken the greatest pains in doing it. There are some big works in the place where they have done everything they could do.

28164. Have they introduced a storage tank ?—It is wonderful the improvement they have made in a great number of these works, but still there are some who do not do it.

28165. If you have some of them who have introduced a storage tank, and allow this acid washing water to flow at a regular speed—if there are some of them who do it—it is clear, it is reasonable and practicable; therefore, what about making the remainder do it ?—If you give us the power.

28166. With your existing powers ?—I have something which I wish to lay before you afterwards, which perhaps will enlighten you.

28167. I do not quite see your difficulty. If you are able to show, by the fact that this is done by some, that it is reasonable and practicable to do it, why cannot you with your existing powers call upon the remainder of the collieries to do it ?—We have no existing powers to do so; we cannot unless we take legal proceedings against them.

28168. That is what I mean ?—Well, if I might hand in, Sir, something—I have to apologise for not being able to have it before—perhaps that might enlighten you as to the proceedings. (*Document handed to Chairman.*)

28169. (*Chairman.*) Shall I read this out ?—If it is not giving you a great deal of trouble, Sir.

28170. (*Chairman.*) "The provisions of Section 14 of the Local Government Act, 1888, which give the county council concurrent powers of enforcing the Rivers Pollution Prevention Acts, do not appear to be conducive to the enforcement of these Acts in any ordinary cases of pollution that are not of great magnitude.

"It would appear from Subsection 2, that the main purpose of inserting this section was to enable a more powerful body financially, to come to the assistance of a weak district council in preventing the pollution of streams by powerful interests, but in the case of minor pollutions which ought to be prevented by the district councils, and are amply within their means, the section practically operates to discharge them from doing their duty, because they can always say to the county council and to each other that, if they do not perform their duties, it is equally the duty of the county council to do it for them and save the local ratepayers the expense and odium of attacking residents in their district.

"To make the powers of the county council effective in such cases as these, I think there ought to be power to charge the expenses of the proceedings, or such part of them as the county council may think just, upon the district primarily responsible for the sanitation and protection of the stream in question.

"Precedents for this form of legislation have been created since the passing of the Local Government Act, 1888. The Isolation Hospitals Act of 1889 authorises a county council, in the absence of an application by a district council to be formed into a hospital Committee, to direct their medical officer to hold a local inquiry and report whether an isolation hospital is required for the district or not, and if the county council on that report finds that such a hospital is required, they have power to appoint a Committee and provide a hospital at the cost of the district. Other precedents are to be found in the Local Government Act, 1894, where, on the report of a parish council, that a district council has failed to perform its duty, the county council is entitled, if they

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find the case proved, to step in and perform the duty of the defaulting district council, at the expense of the rates of that district.

"In the Rivers Pollution Prevention Act, any person interested may set the local authority in motion, and if that authority refuses to take proceedings, may appeal to the Local Government Board, who may order them to do so, and I would suggest that the complaint of the person interested might now be sent to the county council, who should be empowered if they find it proved, to take similar action to that provided in the case of a complaint by a parish council, by the Local Government Act, 1894, in the cases provided for in that Act, at the cost of the district council. If necessary, this power might be subject to an appeal to the Local Government Board by the district council affected, as the Local Government Board is at present the appellate authority under the Rivers Pollution Prevention Act, which was passed before county councils came into existence.

"It does not appear that even a parish council could set Section 16 of the Local Government Act in operation for the purpose of transferring the powers of a district council to the county council in a case arising under the Rivers Pollution Prevention Act, but the cases in which a parish council would take such action would probably be very rare, and the Rivers Pollution Act anticipates that such complaints may be properly made by any person interested, which, I should consider, ought to be continued as the procedure, if it is to have any successful operation."

28171. (*Colonel Harding.*) Your difficulty is not one of powers, but one of cost ?—Yes, Sir.

28172. Your county council is not prepared to undertake the cost of litigation which they cannot saddle upon the district which is benefited by the advantages that would be obtained by the litigation ?—You see, Sir, our county council especially will not go into these questions. We had, unfortunately, a case in point, where we prosecuted and we failed signally. Why we failed it is perhaps better not to say. But since then there has been great difficulty, and I fancy there would be immense difficulty in getting them to move in any case of pollution. We had a case the other day of a town which polluted the river, and after a great deal of hesitation we asked them to prosecute, and they promptly refused to prosecute in this case, Cwmavon. It is very hard to get them to institute prosecutions at all. I think you will find under the River Pollution Act it is very hard to proceed.

28173. If the local authority will not use its powers, I do not quite see what there is to be done ?—We should like to get the Act altered, to make the parish council, the district council, and the county council move. At present you cannot make them move.

28174. (*Chairman.*) Is that because the members of these councils are themselves concerned with the pollution ?—Well, they may have something to do with it.

28175. (*Mr. Stafford.*) Then you require a superior authority to move the county council, and the district council and the parish council ; that is what it comes to ?—We should like something that would move somebody at all events. If somebody did move them, something might be done. At present we cannot do it. We have done something in gas works and those things. We have moved under the Act and done a great deal of good.

28176. What form of pressure do they bring upon them now to do anything ?—Well, we cannot bring any pressure upon them at present.

28177. Is there a certain amount of remonstrance ?—Yes. Well, that does not go far, you know.

28178. Then it is rather a hopeless outlook, if I might say so ?—I think our noble Parliament at present might do something for us. As a gentleman told me, who was one of the great men creating the Bill, he said "You have a capital Bill but we have taken all the sting out of it before we sent it on to you."

28179. Really if even the best of the local authorities, the county councils, will not move—— ?—But they will move.

28180. It is very hard to know what Parliament is to do ?—We want more power ; that is what we want.

28181. (*Chairman.*) Would you suggest that the power should be provided in a Bill to be introduced ?—I should think so. If there were a Bill introduced it would do the country an immense amount of benefit as regards the water. As I say in my paper there, we are on the borders of a water famine. In my country the water is getting very very scarce indeed. The workings of the coal mines, and things of that sort, have destroyed a great many of the local water supplies. We have got a big Bill before Parliament now this year from the Glamorgan County Council, which I sincerely hope will be carried, but if it is not carried I do not know what we shall do in the future. The water supply of the whole of the county is in a very, very bad state.

28182. Is that as regards quantity or quality ?—The quality is bad, and there is not sufficient quantity.

28183. (*Mr. Stafford.*) Is it not very difficult to go to Parliament, and ask Parliament to give you greater powers and fresh powers when you do not exercise the powers you have got ?—We have exercised them, Sir ; we have brought several actions, and we have found them fail for the want of power.

28184. (*Chairman.*) Might I interpose a question here, which I intended to ask before. I think I asked Dr. Williams about the rivers boards ?—(*Dr. Williams.*) There are no rivers boards.

28185. There are no very large rivers ?—They are all short rivers.

28186. Would it be possible to group these rivers into a drainage area, instead of a rivers board, and so consolidate the whole area ? Would that be an advantage ?—Yes, I think it would. You could easily group the small rivers. (*Colonel Lewis.*) As Dr. Williams said, they are mostly mountain streams which flow from the south side of the Brecknock Beacons down to the sea. These are mountain streams, which of course are very liable to flood. The spates come down very much quicker in those than they would in a lengthy stream, and as a rule they are more difficult to deal with. At present we want powers to prevent the tipping into the river of the refuse that is tipped in. That chiefly is done, I am sorry to say, by the local authorities. A great number of the local authorities are always threatening prosecution, and we stop them by threatening prosecution. We stop a great deal, but still it goes on, and there is an immense amount of tipping done on the quiet at the collieries into the river, especially on the Saturday and Sunday morning. On Saturday and Sunday they do not work the inclines which take the usual tippings, and take them on to the hill and throw them out on that ; but in order to save the bother of that it is tipped in when no one is looking.

28187. Into the river ?—Into the river.

28188. (*Colonel Harding.*) What is it that is tipped ?—Refuse of all sorts.

28189. Solid refuse ?—Solid refuse and what is called the sump waste. I do not know whether you know what the sump is. I did not know it till the other day, when it was explained to me. It is what collects at the bottom of the pit—all black oil, all sorts of stuff and refuse—and this is brought up at the end of the week, and it is thrown away, and very often it is thrown into the river.

28190. Carted to the river ?—Carted to the river. As a rule, a great number of these collieries are on the bank of a river.

28191. And you suggest to us that new legislation is required for you to prevent that ?—Yes, Sir, to enable us to proceed.

28192. How about this clause ? "Every person who puts or causes to be put or to fall, or knowingly permits to be put or to fall or be carried into any stream, so as, either singly or in combination with other similar acts of the same or any other person, to interfere with its due flow or to pollute its waters, the solid refuse of any manufactory, manufacturing process, or quarry, or any rubbish or cinders, or any other waste, or any putrid solid matter, shall be deemed to have committed an offence against this Act" ?—Yes, Sir, we prosecuted under that, and lost it. If you could persuade the district council, Sir, to take that matter up, which, of course, it is their duty to do—on all the district councils it ought to be their duty to take this matter in hand—and to say they ought to be responsible for the bit of the river that goes through their district, they ought to be responsible for that under the county council; but nothing is ever done, and nothing is ever reported, except by our sanitary committee. Both the doctor and myself, and the inspectors, go up and down these rivers ourselves, and satisfy ourselves where there is pollution. Our next mode of procedure is to bring it before the sanitary committee. We then pass a resolution to write to the owners asking them to cease, and also warn the district councils that notice has been given to them to cease; and we get an answer to say that it has ceased, and then the next time we go up we find the same again.

28193. Why do you not prosecute ?—We ask the county council, and they refuse.

28194. You have powers under this clause to institute prosecutions ?—It is a very lengthy way of getting at it.

28195. Under this clause prosecutions are certainly instituted elsewhere, and successfully. Can you, or can Dr. Williams, tell us on what grounds you failed when you did prosecute in such a case ?—(*Dr. Williams.*) Yes, I gave that; it is the only case I remember.

28196. That is a question of innocuous discolouration with solid matter ?—Yes.

28197. I understand from Colonel Lewis that you have failed in a case of putting solid matter into the stream. On what ground have you failed ?—I think Colonel Lewis was referring to a case the other day, where a certain rural district council were polluting the river by sewage, and have been doing so for a long time.

28198. That is another matter ?—I think Colonel Lewis must have been referring to that.

28199. He said legislation was required to prevent tipping of certain solid matter into the stream ?—(*Colonel Lewis.*) Of course, you would say we have that power.

28200. You have that power ?—(*Dr. Williams.*) Shall I explain then ? The sanitary committee recommended that prosecution should be taken against this district council, and when it came before a meeting of the county council they would not prosecute. That is what Colonel Lewis was referring to.

28201. They refused to put the law into motion ?—Exactly, and the reason given by this district council was that they could not afford it just now. They were constructing very extensive water works. They could not afford it, but they admitted there was pollution.

28202. It seems to us a good case would be made out for fresh legislation if it were found the existing powers were insufficient, but certain powers are now available which you do not choose to put into action ?—In the case of the Great Western Colliery, which I referred to, it came on since I went there. Well, that was a very big and expensive case, and they did not feel inclined to try it again.

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28203. That is another case; the discolouration ?—That is another case; that is the one I referred to.

28204. (*Mr. Tatton.*) Is the county council composed of colliery owners, may I ask ?—Yes, there are some on, certainly. (*Colonel Lewis.*) A great number ? (*Dr. Williams.*) Oh, yes, there is always a percentage. If they are not owners themselves, they are connected with it. (*Colonel Lewis.*) And tin mine owners, too.

28205. (*Chairman.*) I think we owe you a good deal, Dr. Williams and Colonel Lewis, for having suggested that a rivers board is not quite what is required in South Wales, but something in the nature of a drainage area board. In places where rivers boards have been instituted for some time, they have no difficulty ?—(*Dr. Williams.*) No. I see that from the report of Dr. Maclean Wilson.

28206. But in your case one could not have a rivers board, because there is no long river ?—Well, you could have a rivers board to take in the whole of the neighbourhood where the bulk of the population of Wales live, on that black area of the map there (*indicating on map on wall*), which is about two-thirds of 2,000,000 in the whole of Wales now, *i.e.*, about 1,333,000. That is the very place where pollution takes place, over the coal basin, including a part of Monmouth, a part of Carmarthen, and the whole of Glamorgan. And all our rivers, as I said before, are very short. They are all inside the county, with high mountains at the back practically. They should be easily dealt with.

28207. I do not know, Colonel Lewis, whether you wish to add anything, because practically we have gone over the whole of the matter dealt with in your notes of evidence ?—(*Colonel Lewis.*) I think so; I do not wish to take up your valuable time.

28208. We have gone over the whole of this ?—I think that last paper I handed in——.

28209. That will appear on our Minutes, and we thank you both, Colonel Lewis and Dr. Williams, for your kindness in coming and giving us this very valuable evidence ?—May I make an addition ? I am very sorry to trouble you, but we have had great complaints about some of the rivers where the tinplate works are, as to the cows drinking the water. It is only a report from the farmers themselves, but I have been going round, and they say that, in a great measure, this has brought on abortion among the cows.

28210. That is a distinct damage done ?—Well, that is what they say. They tell me when I go round, and they all complain that cows have drunk this water, and it has brought on abortion on the farm.

28211. Do you think the abortion was due to this ?—(*Dr. Williams.*) I could not say; I should think it was possible, if they drunk it very, very strong. I should think so, but I could not go any further. There seems to be a belief in certain parts that the drinking of tinplate effluent will produce abortion in cows. I have heard it more than once, but I did not mention it myself, as I do not know whether it is correct.

EIGHTY-NINTH DAY.

Thursday, 28th January, 1909.

PRESENT :

Colonel T. W. Harding, J.P., D.L. (*in the Chair*).
Sir William Ramsay, K.C.B., F.R.S.
Mr. R. A. Tatton, M.Inst.C.E.
Mr. F. J. Willis (*Secretary*).

ALSO PRESENT :

Dr. A. C. Houston.
Dr. George McGowan.
Mr. G. B. Kershaw.
Mr. C. C. Frye.

Dr. H. Maclean Wilson, Chief Inspector of the West Riding Rivers Board, recalled ; and Further Examined.

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28212. (*Witness.*) May I be allowed, Sir, to go back to what I said the other day, to make an addition in the case of wool-washing suds ? I believe I said that there was no known method of purifying wool-washing suds to make them fit for the stream, but I had forgotten at the time this Report upon the treatment of wool suds by evaporation, a method which has been patented, I believe by Mr. Walter Leach, the Chemist to the Woolcombers, Limited, Bradford ; and in that Report you will find that a certain class of wool-washing suds, from a greasy wool containing a great amount of grease and potash, can profitably be dealt with by evaporation in a special Yaryan evaporator, and in that process potash is recovered, all the grease and the distilled water.

28213. (*Chairman.*) That has been found practicable in that particular case only ?—In that particular case only.

28214. Are there any special circumstances there which facilitate the treatment in that way ?—I am afraid you will find, Sir, that even in that case where this apparatus was in use—it is not now in use—it was only profitable to use this apparatus when the most greasy wool was being scoured. The suds from wool that has been scoured before, or wool that has been taken off dead skins, cannot be economically dealt with in such an apparatus.

28215. Then you do not suggest it as a practical method for general use ?—Certainly not.

28216. On account of the cost ?—Yes.

28217. (*Sir William Ramsay.*) Is there a process in use for extracting grease from wool by sulphide of carbon, or has that completely gone out ?—It is in use at Verviers. I forget whether it is by sulphide of carbon or some other solvent, but it is not in use, so far as I know, in this country.

28218. (*Chairman.*) Then the benzine process which you went to see at Roubaix ; has that been extended at all and applied in this country ?—That was for extracting the grease from the wool suds ?

28219. Yes ?—No, that has not been applied at all in this country. It was tried, you know, at the Bradford Sewage Works for the extraction of the grease from the Bradford sludge, but it was not found successful.

28220. No progress has been made in that direction ? —No, none at all that I know of.

28221. Then we are to take it that this treatment of the wool-washing waters, especially of the crude wools, is still a source of great difficulty ?—That is so.

28222. (*Mr. Tatton.*) Have you any rivers or small streams in your watershed which used to be highly polluted by untreated waste from wool scouring and wool washing processes, that are now clear, or at any rate do not cause a nuisance ?—I am going to mention one or two of those. There is a question in those sent to me with regard to the improvement of the streams.

28223. That will come up again ?—Yes. I have some of them. Then, Sir, may I also make an addition with regard to chemical refuse ? I omitted to give you another great and increasing source of pollution from chemical refuse. The Commission knows of the Mond plant for procuring power gas from lower forms of fuel, waste coal and such things, and there are now three of these in the Riding ; Mond or Duff's plant. There are two forms of the same plant, and from these large amounts of very polluting chemical refuse are discharged. One is at Farnley Iron Works, Leeds ; one is at Vickers, Sons & Maxim's, Sheffield, and the other at John Brown's, Sheffield ; and I am glad to say that in all these three cases the manufacturers are doing their very utmost to prevent any pollution of the stream by this chemical waste, and I think are succeeding.

28224. (*Chairman.*) In what way ?—Chiefly in the way that I suggested for the using up of the chemical refuse, that the dirty water is partially purified, and circulated and re-used, and finally some of it evaporated.

28225. (*Sir William Ramsay.*) Does the dirty water come from the recovery of the ammonia ?—Yes, it is from the recovery of the ammonia.

28226. I presume the ammonia liquors are neutralised with lime and distilled ?—The ammonia is caught in sulphuric acid and the sulphate of ammonia recovered by evaporating the accompanying water.

28227. And the residue which distils is tarry ?—The dirty water which is distilled over.

28228. Then that can be used again after partial filtration ?—Yes, that can be partially purified, and made fit for many uses.

28229. For many uses. Ultimately I suppose it gets pretty well charged with sulpho-cyanides and cyanides and becomes unusable ? — Yes, and in one case in connection with this Duff plant, the excess when it becomes so charged is used for cooling furnace slag. In another case, they have sunk a cylinder into some old coal workings, and are discharging it in there.

28230. (*Chairman.*) In view of the great difficulty in dealing with these final residual liquors from the coal washings and the gas works, you think perhaps it is the most hopeful direction to work in to so far purify the liquors as to permit of their being used for other purposes in the same works ?—I am quite certain of that.

28231. And I think you gave us instances where that had been successfully accomplished ?—Yes.

28232. And in this case of course there is no effluent and no pollution ?—That is so.

28233. (*Sir William Ramsay.*) Have you any analysis of those liquors when they become concentrated ?—I am afraid not.

28234. I was wondering whether it would not pay to recover the cyanides and the sulpho-cyanides ?—In that connection, Sir, I would like to refer you again to the paper of Mr. Kochs. Briefly put, his method is not to use any water for scrubbing gases at all, but in connection with these patent coke ovens to take the gases direct from the coke ovens and pass them through sulphuric acid in a saturator, where the ammonia is caught and the gases pass on. That does not do away with all the gas liquor altogether, as you are aware, because there is gas liquor which comes from the moisture which has been in the coal, and from the moisture of the water of ignition, but it reduces, he claims, the amount of gas liquor by something like 70 per cent. I have just written to him to ask him if he had considered in that connection whether with the much reduced volume of gas liquor, it would not pay to recover the cyanides, and he said he had not given his attention to that; but it is well worth attention.

28235. Does it not give a very impure sulphate of ammonia?—He says purer.

28236. Oh, purer?—He says purer. Such a kind of coke oven is being erected in the West Riding at present, and will be going within six months or so.

28237. You have just been telling us about the direct neutralisation of ammonia. Dr. McGowan asks me to put this question. Is Dr. Grossmann's proposal, to neutralise the original ammonia water direct from sulphuric acid without distillation, operative?—I believe they had a process of that kind at Carlisle Gas Works. I found some reference to it and made inquiry, but they have abandoned the process. It is, however, used in the Mond and Duff plant.

28238. (*Dr. McGowan.*) Was it abandoned at Carlisle because the sulphate of ammonia was too tarry?—I do not know their reason.

28239. (*Chairman.*) Among the uses to which the residual liquors are put in collieries is the use of it for quenching coke?—Yes, very often.

28240. You have not noticed any objection arise from that, have you?—No, I have made careful inquiry, rather fearing that there might be some harm arising to the workmen, but I have never found a case.

28241. And what effect has this use of the water upon the coke itself; does it reduce its value?—The manufacturers of the coke tell me that to some extent it spoils the appearance. Good marketable coke should have a fine metallic lustre, and they say that the use of this spent gas liquor makes it brown, but none of them have said that it affects the actual value of the coke, except for its appearance. On the other hand, some of these colliery proprietors who do use up their gas liquor in this way have told me that it has never affected either the appearance or the value in any way.

28242. We might then pass on to some of the other sources of pollution in the West Riding, and let us first take brewing. Now how many breweries have you in your area, and will you tell us how many are connected with sewers, and how many discharge into the streams?—I am afraid I have mixed them up rather in my report. I have put brewing, malting and grain washing places altogether.

28243. Will you please deal with the whole of that class?—There are 247 of them altogether, and of these 149 discharge into sewers.

28244. And the remainder, I take it, into streams?—Yes.

28245. What is the number?—There are ninety-eight discharging into streams.

28246. Now, with regard to those that are connected with the sewers, is the volume in any case so large as to materially affect the treatment of the sewage at the sewage works?—There is one special case, again at Rothwell, where I said one of their sewage works was affected by chemical refuse, another set of sewage works is very seriously affected by brewery refuse, and there again the results have been so bad that the sanitary authority have been compelled to apply to the Local Government Board for a loan for the improvement of the works.

28247. What does it involve, the enlargement of the works, or the modification of the process?—Both, Sir. Their present method of treatment is by chemical precipitation and settlement, and by distribution of the tank effluent upon land. That has been found very ineffective in its results, because there is a great deal of putrefaction goes on in this brewery refuse, and it becomes exceedingly offensive when applied to the land. They therefore—partly I may say at my suggestion—are putting in percolating filters. They are going to keep, I believe, to the chemical precipitation, but they are introducing percolating filters between the tanks and the land.

28248. Have any experiments been so far carried out on those lines?—Yes, Sir. I sent the Commission a report some years ago upon some experiments that I have made upon brewery refuse.

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28249. On quite a small scale?—On quite a small scale.

28250. But they were sufficiently encouraging to lead you to think that this probably also would be satisfactory?—Precisely.

28251. At present there is nothing that we can see?—Well, there is, Sir, at Messrs. Senior's brewery at Shepley. I have just got them to put in a biological method of purification of brewery refuse.

28252. But that is for brewery refuse by itself?—By itself.

28253. Then there is nothing that we can see in your district for the treatment of the combined brewery refuse and sewage on percolating filters?—No, Sir, I do not think that there is any place where the proportion of brewery refuse is so great as to make it worth your while to pay a visit.

28254. In all the other cases we may take it that the volume of brewery refuse introduced into the sewers does not affect materially the treatment in the sewage works?—Yes, I think that is so.

28255. Then passing to the cases in which the brewery is not connected with the sewers, what are the methods of treatment which have been adopted in your area?—I may say that there are comparatively few breweries that are not connected to the sewers.

28256. I think you told us there are ninety or more?—Yes, but I should perhaps have explained that those ninety-eight cases where the premises discharge to streams probably include more malting and grain washing premises than brewing, and in the case of malting especially and grain washing, my board has really taken very little action. The effect of these discharges on the streams, generally speaking, is not very great.

28257. Then do they first settle before discharging?—Yes, they settle or strain the malting refuse; but if you will allow me to finish, Sir, about the brewing, these places in the Riding where the brewing refuse is discharged into the streams, I think in every case have purification works. They are not very big, and they have settlement of the refuse with irrigation upon land in most of these cases. But in one special case, Messrs. Senior's brewery at Shepley, I have just got them to adopt a very full method of biological purification. That is, they first collect the refuse in tanks and precipitate it, and neutralise it with lime, and they then irrigate the tank effluent upon a percolating filter with a sprinkler; a coal filter. They take that filter effluent, and further spray it upon a coke filter. I have a report upon these works in the printers' hands now; I had hoped to have it ready for you, but I am afraid the works have not been going long enough to make the results of treatment very trustworthy; but I hope and believe that they will be able to get a perfectly good effluent to discharge into the stream.

28258. In the case of malting liquors, is settlement sufficient by itself without further treatment?—No, Sir, the liquor from malting—that is the liquor in which barley has been steeped before it is turned into malt—is a highly organic liquid, and it is peculiar in this way. If it is discharged into a considerable volume of water, then it produces no perceptible effect. It seems to be rapidly oxidised when it is dissolved and diluted by a lot of water, but if it is discharged into a small or stagnant stream, it becomes very putrid and offensive. In some of these cases we have got the manufacturers to adopt means of purifying their refuse. In other such cases we have got them to connect it up to the sewers, but in the case where they discharge into comparatively large volumes of water I think the Rivers Board has taken little or no action.

28259. As a fact, do they simply settle at present?—Yes, in these latter cases.

28260. But if you have reason to think that brewery refuse can be satisfactorily dealt with on percolating filters after settlement, you would probably expect a good result, a better result, from the treatment of this malt liquor?—That is so.

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28261. Have you any instances to which you can refer us where the brewery refuse is satisfactorily treated on percolating filters after sedimentation, or are the works all in progress only ?—In this case of Messrs. Senior's brewery at Shepley, they are very complete works, and they have been in operation perhaps three or four months.

28262. Would that be the best place for us to see them ?—I hope you will see that place.

28263. And would that be a typical instance of dealing with brewery refuse, so as to guide us with regard to other districts ?—Yes, it would.

28264. There are no special circumstances at Messrs. Senior's ; just the usual circumstances attending breweries ?—Yes, the ordinary circumstances. They have plenty of room and plenty of fall, which is an important matter, although by pumping the question of fall can be got over.

28265. (*Sir William Ramsay.*) Might I ask what brewery refuse consists of ? I do not know that we have had that question apart from the steep liquors ?—There is a report published upon brewing that I sent in some years ago, and you will find that I have mentioned that in many breweries there is a malt kiln attached, so that you have the steeping water which comes from the malt kiln ; that is one form. Then, Sir, the malt is mashed with water to make an extract of it, and after it has been mashed and the extract is removed as much as possible, there is always some liquid draining from it which forms another part of the refuse. Then in the fermenting vessels where the yeast is added there is a great deal of dirty water comes from the washing of them out. Then again there is a lot of water from washing out the cooling apparatus.

28266. Washing the surface of the cooling apparatus ?—Washing the surface, yes. Then again in the cellars there is a good deal of spilling on the floor and water used for washing the floor. But perhaps the biggest discharge of dirty water is from the washing out of casks. Casks come in from their customers with a good deal of beer left in them, stale beer, hops, and so on, and these have to be exceedingly thoroughly washed out—sterilised in fact very often—washed out with steam. A great deal comes from that.

28267. Then is the deposit which is left after the beer has settled after fermentation made use of, or is it run away ?—That is chiefly a yeasty deposit.

28268. Yes ?—And in some breweries, at least formerly, it used to be run away down the drains. In a great many cases they remove it, and either sell it or deal with it rather as solid refuse. It should certainly not be mixed with the liquid refuse ; it greatly adds to the difficulty of treatment. You know, Sir, from your experiments on the distillery refuse that the chief difficulty in dealing with brewery refuse is the acid fermentation which takes place, and its exceedingly offensive character.

28269. (*Chairman.*) You have told us that in several cases where breweries are unconnected with sewers their effluent has been successfully treated by distribution on pasture ?—Yes.

28270. Then tell us how it is that at Rothwell, where you have brewery refuse mixed with sewage, they left off dealing with it on land. First of all, what was the nature of their precipitant ?—I believe the precipitant was chiefly lime, but I am not quite sure whether they did not add alumino ferric as well, but the cause of the failure was two-fold. First they received this brewery refuse into large settling tanks, and I think they perhaps were not sufficiently careful to prevent the acid fermentation, and the brewery refuse and sewage mixed became very putrid, exceedingly offensive. Then to deal with that large volume of putrid liquid their land was not adequate.

28271. Then the objection to the process was not that treatment on land was ineffective, but that in this particular case there was not sufficient area to make it effective ?—And in any case it would require a very large area—a very large area. The most classical instance, I may say, is at Burton-on-Trent, where they have had several times to increase their farm ; and they found it advisable not to pass the refuse through tanks, I suppose, because they would find that caused putrefaction ; but they added lime to the refuse in the sewers.

28272. And in large quantities ?—In huge quantities ; from memory, 50 to 60 grains per gallon, and pumped the sewage directly on to the ground without any settlement whatever.

28273. Then that involves that the land shall be suitable ?—Suitable and of a very large area.

28274. Is the land at Rothwell unsuitable ?—I should not say so, rather that it is medium land.

28275. And there is not enough of it ?—That is so.

28276. And generally, for that reason, you prefer these percolating filters in your district ?—Yes.

28277. Then, speaking generally, you take a hopeful view in regard to the purification of brewery refuse ?—I think you will be able to convince yourselves that it is quite possible to purify it thoroughly.

28278 (*Sir William Ramsay.*) In the case of the successful use of land, is it possible to work the land from a farming point of view, or merely from the point of view of sewage disposal ?—In this case at Rothwell, there is some attempt to farm the land, but it is much too small an area of land to be able to crop it, as well as to dispose of the sewage upon it.

28279. (*Mr. Tatton.*) Then in the case of Rothwell, when you suggest putting a percolating filter between the tanks and the land, that is really more perhaps so as to reduce the volume on the land ?—There would be the same volume on the land, but it would have the previous purification from percolating filters.

28280. Then would you not anticipate having a nuisance also from the percolating filters ?—I think not. If they are sufficiently careful to neutralise the brewery refuse before putting it on the percolating filters, if they will prevent the acid fermentation, there should, I think, be little or no nuisance arising.

28281. Of course, in some places, as you probably know, they have had a nuisance ?—Yes, there is great danger of a nuisance. It requires very careful chemical treatment to prevent this acid fermentation. It is most remarkable how rapidly that acid fermentation takes place. You may neutralise the brewery refuse as it comes from the brewery. By the time it has passed through a comparatively small tank it has become acid again.

28282. (*Chairman.*) You have spoken to us about chemical precipitation in connection both with brewery refuse, and the mixture of brewery refuse with sewage, but you have not said anything as to the use of septic tanks, either for the mixture or for the brewery refuse alone. Have you any experience of the use of septic tanks for that purpose ?—Yes, Sir, a rather sad experience. In the case of the brewery in which these experiments on which I have reported were carried on, Mr. Berrington, of Wolverhampton, a well known sewage engineer, put them down septic tanks and contact beds for dealing with their refuse ; costly works comparatively. They were found quite hopeless for the purpose. The passage of the brewery refuse through these septic tanks made it so very offensive—and they were in the neighbourhood of houses—that they had to abandon their use. As a matter of fact, I believe I mention in the report that they were threatened with an injunction, because of the nuisance they caused, and we found also that the results they got from the septic tank and contact bed treatment of brewery refuse—double contact—were quite ineffective, quite insufficient.

28283. Have you any other instances of the treatment of either brewery refuse, or brewery refuse mixed with sewage, in septic tanks ?—I do not think so, Sir, except that these tanks at Rothwell may very well be called septic tanks. The sewage becomes very septic in them ; it always becomes most offensive and very acid.

28284. Notwithstanding the chemical precipitation ?—Notwithstanding the chemical precipitation. It was this case that I was referring to at Rotherham, where I said we used lime to neutralise the refuse as it came from the brewery. By the time it had passed through the septic tanks it had become highly acid again and putrid.

28285. (*Sir William Ramsay.*) I suppose the refuse effluent from any form of chemical precipitation is highly nitrogenous, is it not ?—Oh, very.

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28286. So that it ought theoretically to be a good manure ?—Yes, theoretically, it should do good to land, but I think the main reason that it is bad to apply it to land is that it causes a nuisance.

28287. (*Mr. Tatton.*) Were those covered septic tanks or open that you instance, that were a source of nuisance or caused a nuisance ?—They were open, but the nuisance was not so much from the tanks themselves—it never is in the case of septic tanks, as you are aware—it was from the tank effluent as it was applied to the filters, and from the cleaning out of the septic tanks. In these cases very frequently the septic tank sludge, sewage sludge, is not offensive, but this was most horribly offensive.

28288. (*Chairman.*) There is another class of offensive effluents of which you have many instances in your district, that arising from the treatment of leather. Now what about tannery refuse, fellmongers' refuse, and so on ? You have a considerable number of sources of pollution of that kind in your district ?—There are 143 premises where the business which is carried on is some branch of the leather trade. That includes tanners, curriers, and fellmongers.

28289. In how many cases are these works connected with sewers ?—Ninety-two are connected with the sewer, leaving fifty-one discharging into streams.

28290. Now, in regard to those fifty-one that now discharge into streams, is there any prospect of any of them being connected to sewers ; is there practicability to be connected to sewers ?—Oh, yes, a considerable number of them will be as I mentioned the other day, in the cases of Huddersfield, Halifax, Heckmondwike and Dewsbury, where the Corporations are going to take all trade refuse into the sewers, and in this number of fifty-one a good many cases are included of that kind, and the tendency is to take such things into the sewers.

28291. In the case of those effluents, you have no reason to think that their admixture with sewage causes a difficulty at the sewage works ?—Not in any reasonable proportion. It would cause difficulty if they were in any large proportion, but we have no such cases.

28292. Then the policy, you think, with regard to these effluents is as far as possible to get them admitted to the sewers ?—I am quite certain of that in my own mind. These liquors are very difficult to treat by themselves.

28293. Then there must remain certain cases where the effluents will have to be treated by themselves ?—There will always be some cases where sewers are not available.

28294. In those cases, what method of treatment have you found to be either practicable, or partially practicable ?—In the case of tanners, I think I may say we have not found any method effective, except chemical precipitation and treatment upon land, or treatment upon land by itself ; and fortunately the only tanners who are left out of the sewers in the West Riding are in a small way of business, and I think, from memory, all their refuse is fairly well dealt with by irrigation upon areas of land. Now in the case of fellmongers we have a considerable number of fellmongers in the Riding who are not effectively dealing with their refuse. They are settling all the lime—there is a great admixture of lime in fellmongers' refuse—and they are settling all the lime and roughly straining the effluent in most cases, but the resulting effluent is still very far from satisfactory.

28295. You have within the borough of Leeds, on the Meanwood Beck, a good many fellmongers ; are they now connected with the sewers ?—I think so, without exception.

28296. Is there not one at the head of the stream ?—Oh, no, that one is abandoned now ; the works have been removed elsewhere ; the Meanwood Tannery it is.

28297. The one I visited with you once ; has that been stopped ?—That has been abandoned.

28298. That is abandoned ?—The work is removed to another set of premises, and there is only one from memory ; there is Messrs. Flitch's tannery, where the refuse is dealt with and discharged to the stream.

28299. Is it discharged in a satisfactory condition ?—No, it is very far from satisfactory. The position is rather difficult, because Messrs. Flitch have erected works—settling tanks and patent filters—for dealing with their refuse, and they take out most of the solid matter, but there are still all the dissolved organic impurities, and the effluent is very unsatisfactory. They are prevented they say from getting into the sewer because of their fear of the Aire and Calder Navigation, who say they have a right to the liquid ; as long as it is free from solids it is sufficiently good to float their ships.

28300. The same objection was raised, I believe, in regard to other tanneries if I remember right. There was some communication with the Canal Company, and without abandoning their rights they seemed inclined to waive the point, did they not ?—I do not know what has taken place, Sir ; I think the manufacturers have ignored any rights ; I think the Aire and Calder Navigation are perhaps claiming more than is their due ; at any rate many have connected up their premises to the sewers.

28301. Why is that particular tannery not connected while neighbouring tanneries are connected ?—I cannot say that either. I have pressed Messrs. Flitch to be connected to the sewers, but they have always professed they were afraid of the Aire and Calder Navigation.

28302. I suppose we may take it that it does not pay to withdraw any of the matters from this class of effluent ?—No.

28303. There is nothing that can usefully be withdrawn ?—No, the treatment entails a cost without any counterbalancing profit.

28304. Well then so far as tanneries are concerned, there are only a few small tanneries left, and you say they are in a situation where the land is of sufficient area to enable them to satisfactorily deal with their refuse ?—That is so.

28305. But with regard to the fellmongers I rather gathered that there were instances where unsatisfactory effluents were being turned into the streams ?—Yes, there is one discharge of a similar nature on the Meanwood Beck, but that I believe is shortly to be connected up to the sewer.

28306. Then have you any instance which you can refer us to where either tannery refuse or fellmongers' refuse is being dealt with satisfactorily ?—I think, Sir, you will find much better instances in other parts of the country. As I say, the tendency has been all along in the West Riding to connect up these premises to the sewers, and I do not think there are any cases that it would be worth your while to visit.

28307. As regards the pollution of streams, tanneries' and fellmongers' refuse does not affect you seriously in the West Riding ?—Well, fellmongers' does. There are a good many cases of fellmongers whose refuse is discharged into streams after simple settlement, but I am sorry to say I have no cases where I can show you that kind of refuse being properly dealt with.

28308. But you said that in many of these cases there was a probability at least of connection to sewers ?—Yes, but that applies less to fellmongers than to tanneries. May I instance a case, Sir ? In Sheffield we have a fellmonger who is hemmed round on all sides by other buildings, other manufacturing premises. He has put in settling tanks and rough straining filters, and with them has occupied the whole of the free space at his disposal. His effluent is still very bad, so bad that the Corporation of Sheffield has complained to the Rivers Board of the nuisance it causes. I am scarcely able to advise my Board that he can reasonably do much more on the area at his disposal.

28309. Why does he not connect with the sewer ?—I was going to say that the Rivers Board at my suggestion has advised the Corporation that they should at least consider the question of allowing him to connect with the sewer like other manufacturers in Sheffield. They are very unwilling to do so. I think they are chiefly guided by two reasons. He draws water from a little stream, and they are afraid of his turning great volumes of water into the sewers. But perhaps more than that they are afraid of his turning the lime that is in his refuse into the sewers, where it would very probably set like a cement and cause stoppage of the sewers. The matter is there

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at present. We have lately again received complaints from the Corporation, and we have again urged them to consider whether they cannot under proper regulations allow him to connect with the sewer.

28310. Is this lime difficulty one that applies to fellmongers' refuse in all parts?—It always does; their refuse is always full of lime.

28311. (*Sir William Ramsay.*) In solution and in suspension?—Both in solution and suspension.

28312. (*Chairman.*) I suppose it would be quite easy to eliminate that?—All that is in suspension.

28313. Yes.—And I think fellmongers' refuse would also lend itself very well to percolating filter treatment.

28314. But you know of no instance in your district?—No, Sir, I am sorry I have no instance.

28315. (*Mr. Tatton.*) In your Report on the Leather Trades, p. 33, you give us the conditions under which the effluent from the works is admitted into the Leeds sewers?—Yes.

28316. Do those still hold good in those parts; are they still in force?—They are still in force, but I am not quite sure that the Corporation have not made stringent conditions since they have had a special sewage works engineer.

28317. Well, now, I see that the tanks have to be provided sufficient to hold two days supply, Clause 4?—Yes.

28318. Now, would not that practically exclude most of these fellmongers from admittance into the sewers?—There is a considerable volume of water used at fellmongers' works?—Well, I know you are thinking of such fellmongers as you had at Milnrow.

28319. I was.—We have no places like that.

28320. They do not use so much water?—No, the quantity discharged from any fellmonger's premises in the West Riding is nothing like that.

28321. It is small?—It is comparatively small.

28322. Are they smaller works? I mean, do they deal with a smaller quantity of material; altogether, are they on a small scale?—I think it must be that. I do not think the processes are very different, but I know we have none on such a scale as at Milnrow.

28323. Then do you think it is necessary for them to have settling tanks of that large capacity?—Well, that has always seemed to me rather a large capacity. I think a day's flow would be ample, with proper arrangements for keeping them clean of sludge. I daresay the reason that the Corporation have for adopting such a regulation is that it is exceedingly difficult to keep a manufacturer up to the mark in the way of cleaning his tanks and keeping them clean, and I have no doubt they thought that if they had sufficient tank room they would be better able to insist upon the manufacturer removing the sludge. They would have a greater safeguard that the sludge was not discharged into the sewers.

28234. But in the case of large works, of course the difficulties would be considerable?—They would be very considerable. I think myself that that is too large, that they should have tank room for two days' flow.

28325. (*Sir William Ramsay.*) Does it press heavily on the fellmongers?—I do not remember that we have any fellmongers discharging into the sewers under these regulations. I think not.

28326. But do the regulations as they stand press heavily on the tanners or fellmongers?—Well, I do not think any of them comply with these regulations, Sir.

28327. (*Chairman.*) It is well to bear in mind that these regulations are not like the laws of the Medes and Persians—unalterable; but they show what is to be aimed at, and I have reason to think that the Corporation of Leeds is elastic?—I believe it is so, Sir, and in this case that I mentioned—the manufacturer who is about to be connected with the sewer—I feel quite sure that they will have to relax them, because in his case he has very little room to construct works, and as a matter of fact has to construct his tanks above ground. It would be an exceedingly costly thing for him.

28328. (*Mr. Tatton.*) And pump?—And pump. It would be an exceedingly costly thing to construct tanks for two days' flow above ground.

28329. Then at other places where fellmongers are admitted into the sewers, they have restrictions as regards these settling tanks?—No, I think they have not. I do not remember any.

28330. They turn it in direct just as it comes from the works?—I think they all have some kind of settling tanks, but under no formal regulations.

28331. Then do they cause difficulties at the outfall works? I mean to say, is the treatment of sewage rendered more difficult in consequence of this fellmongers' waste?—I cannot remember a case; no, I have no special case in mind.

28332. As a rule, the sewage is of large volume compared with the fellmongers' refuse?—That is so.

28333. (*Chairman.*) Let me pass to another class of trade refuse. We have heard a good deal within the last day or two of the difficulties connected with effluents from large paper works, where the volume is very large, and where the pollution is considerable, and the treatment somewhat difficult. You have paper mills in your area?—Yes, Sir.

28334. How many?—Twenty-six. Eight of these discharge into sewers, and eighteen into the stream.

28335. Are those eighteen that discharge into the stream large concerns turning out a large volume?—Well, Sir, they are not large compared with paper mills in Lancashire and Midlothian; they are all small in comparison with them; but some of them produce very great pollution of the streams.

28336. Then tell us what has been done in those cases?—There are two cases that I have specially in mind, because each of them is at the top of a stream, the water of which is afterwards used for manufacturing purposes In both cases we have grievous complaints from the users of the water of the pollution caused by the discharges from the paper mills. In the one case they have constructed a very large area of settling tanks excavated in the ground, and they settle the solids out of the refuse to a very considerable extent; but largely, I think, because they do not sufficiently attend to the cleansing of these settling tanks, there are polluting effluents; that is, effluents that are polluting because of their suspended solids still discharged into the stream and causing trouble. In the other case they have gone to a great expense in the purification of their refuse. In the first instance they put in an evaporating plant for the recovery of the caustic that is used in boiling the materials for the paper, and then they put in a very large set of settling tanks in a very awkward situation, and these have been quite insufficient to produce a good effluent. I think I may say that simple settlement is the ordinary means adopted in the Riding, and it is not sufficient to produce an effluent fit for the stream in most cases.

28337. Has, in any case, any material been recovered from the waste waters, which has been of value to the manufacturer?—Yes; caustic.

28338. Only that?—No, not only that.

28339. Any fibre?—Yes. In some cases the pollution used to be very great indeed. You are aware, Sir, that in some of these other paper works in Midlothian, and I believe in Lancashire, large quantities of esparto grass are used which have to be boiled in caustic. We have nothing of that in the West Riding. The materials that are mostly used, I think, now in the West Riding are those from wood pulp, and there is not much polluting matter comes in solution from that material. It is a question of stopping back the fibres. Now, in several cases where they used to pollute the streams very greatly they have gone to the use of wood pulp, and in connection with their paper machines they have put in fibre-saving apparatus; and in one case—Messrs. Marsden's Mills, perhaps the biggest paper manufactory in the Riding—their manager has told me that they make a saving to-day of something like 2 or 2½ per cent. on their output because they recover this wood pulp.

28340. Was this recovery of the wood pulp in consequence of pressure by your Board ?—Yes, it was because of our complaints that they were discharging these polluting liquids containing fibre into the stream.

28341. Has that been adopted in other works ?—It cannot, unfortunately, so the manufacturers tell me, be adopted in all the works. It depends upon the class of material they are using, and upon the kind of paper they are making, but it is gradually spreading. There are a great many mills now where they use this pulp-saving apparatus.

28342. That is one really practical way of reducing the pollution from the effluents of paper mills ?—It is, Sir, and I think you will find from the manufacturers themselves, in certain cases at any rate, that the use of such apparatus has saved them hundreds of pounds a year.

28343. Now, beyond that point it does not pay to settle the effluents ?—No, Sir. You see, the discharges in the case of paper works are chiefly three-fold. There is the discharge from the boiling of the materials used for making paper.

28344. (*Sir William Ramsay*). With soda ?—With soda usually, and lime ; very frequently lime. That is a highly polluting liquid. It is not great in quantity, but it is very highly polluting. Then these materials after having been boiled, are put into beaters where the fibres are all separated and the dirt washed out, and from these beaters there is a large volume of polluting liquid. Absolutely nothing can be done towards the recovery of anything valuable from that liquid.

28345. Might I interrupt you here, and ask whether methodical washing is ever resorted to in these beaters, so as to use the weak waters before treatment of the partially purified materials ?—Yes, that is so ; several paper manufacturers have done that.

28346. With success ?—With success. It saves them water, and it saves them some of the material. Then the third source of polluting discharge is from the paper machine itself. It seems that in making paper an excess of liquid containing the pulp has always to be applied. At least, in every machine there is an overflow, and formerly that overflow used in most cases to be discharged directly to the streams. Now it is there that the economy has come in, because that overflow is clean water containing pulp, and in several cases in connection with each machine they have put in a very simple and effective pulp recovery apparatus, and they settle all the pulp out of the water, let the water run, and return the pulp to the head of the machine again. I would suggest, Sir, that the Commission should see that in the West Riding—should see Messrs. Marsden's works, either at Crigglestone, near Wakefield, or Barnsley, where the pollution used to be very great indeed, and is now enormously reduced.

28347. (*Chairman.*) And what is the condition of the effluent now ; has it been effectively settled ?—Yes.

28348. And does the withdrawal of the suspended matter leave it in a condition permissible to be turned into the stream ?—I cannot say, Sir, it is very satisfactory, but it is in such a condition that if it is turned into a large volume of water it does no very great harm.

28349. Is there a large volume of water in that particular case ?—In Messrs. Marsden's case there is a considerable volume ; in the first two cases there is not.

28350. Is it of a kind to be allowed, in case there is sufficient dilution of the stream ?—I should say so. I should say, Sir, when I am talking of these trade pollutions, to make it quite clear, that so far the Rivers Board have really paid very little attention, have made very little complaint of matters in solution in a trade refuse. They have aimed in the first instance at getting all the solids in suspension withdrawn. There are exceptions. For instance, the Board have complained strongly of acid effluents being discharged from soak plant, because they injure the water very greatly for the use of others below, or in some cases of the discharge of very caustic liquids, but as a general rule they have chiefly drawn attention to the discharge of suspended matters in trade refuse.

28351. Then with certain exceptions, we may take it that trade effluents contain their impurities largely in the form of suspended matter ?—With exceptions.

28352. Yes, certain important exceptions ?—Important exceptions ; these organic impurities.

28353. And if the effective settlement of suspended matter could be obtained, it would lead to a great improvement in the condition of the streams ?—An enormous improvement.

28354. (*Sir William Ramsay.*) Are the soluble matters from the paper manufactory fermentable ?—I think not, Sir. I know of no case where putrefaction takes place in the effluent discharged into a stream after the solid matters have been removed. I think if the solid matters are discharged, putrefaction will take place.

28355. (*Mr. Tatton.*) Have you any brown paper mills in your district?—Well, there are many small mills where they make what is called press paper ; that is a brown paper which they use in the woollen mills for putting between the cloth and pressing it.

28356. Yes, but not the heavy brown paper ?—I think not ; not such as you know it. Our mills are usually very much smaller than the Lancashire mills. Such mills as they have on the Darwen for instance are much larger, and the Midlothian mills are very much larger than ours.

28357. (*Chairman.*) Now, are there any other classes of pollution beyond those on which I have questioned you that you would like to call our attention to ?—I think, Sir, you have spoken of the most polluting kinds of refuse.

28358. Does iron liquor arise in your district to any important extent ?—No, I cannot say it is a very serious pollution now, Sir. The quantity coming from any single place is comparatively small, and in nearly every case sufficient is done by the manufacturer to prevent any serious pollution of the stream. There are a few cases.

28359. And in many cases, I suppose, the ferrous-sulphate is withdrawn ?—By neutralisation, yes, by adding lime.

28360. By evaporation ?—In very few, I am sorry to say. I pointed out in a report that I sent in some years ago that it could be done, and that it is done in one or two cases, but as a matter of fact very few manufacturers have adopted that method. I think it would certainly pay for itself, but there is not much profit in it. The price of copperas is very low, and they will not take the trouble.

28361. We heard yesterday that in the county of Glamorgan that was pretty generally done, and we gathered that it was done with some profit, if not a large one ?—There, I believe, Sir, they have much larger pollutions of that kind than we have—much larger places, where it probably would pay better to adopt such means. Our places are mostly places from which the discharge is small.

28362. And the volume of the stream probably relatively large ?—Yes.

28363. And in many cases there is connection with the sewers ?—Yes, in a great many cases.

28364. There is an important class of trade effluents to which as yet no reference has been made, namely dye waters. Now the volume from dye works is very large, is it not ?—Oh, very large.

28365. And what is generally the character of the effluent ; does it consist mainly of discolouration, innocuous or otherwise, or is there to any extent suspended matter ?—There is a great deal of suspended matter in all dye waters. You will find, Sir, I have no

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doubt that many of the dyers will tell you that they do not discharge any solids whatever in their waters, because the whole processes of dyeing have altered, I was going to say entirely, but to a very great extent during the last ten or fifteen years. Whereas they used formerly large quantities of ground wood and such materials, they now almost always use soluble dyes, and the dyers will scarcely believe you when you show them the amount of sludge that can result from their dye waters, because they are accustomed to put a handful or two of these soluble dyes in their dyeing vessels, a large quantity of which appears to be taken up by the goods dyed, and they cannot see where the solid matter comes from, but the fact remains that in every case where dye water is discharged into a stream there are considerable amounts of solids in suspension.

28366. Then as a fact do the dyers for the most part now settle these ?—They do in most cases, except those cases that are to be connected to the sewers. They have purification works, some of them very excellent.

28367. I suppose in urban districts dye houses are now for the most part connected to the sewer ?—That is so, Sir. I was going to point out that although at first sight it would seem that there is no profit at all to be got from the purification of dye water, that nothing can be recovered of any value, yet in a large number of cases the process of purifying their dye waters may be profitable to the manufacturers. I have given you one very considerable instance in this report upon Waite's apparatus, where the manager of the works has told me himself that he is very satisfied that he was made to put in purification works, because in this case they buy their water supply at a considerable cost, 6d. per 1,000 gallons I believe it is, and instead of buying such a large water supply they can purify their effluent and use it for many purposes ; and that would be so, Sir, in the case of most dye houses where the water has to be bought. I also sent in a report upon the purification of dye waters at Bowling Dye Works. There a considerable proportion of their refuse is purified and used over again. You see, Sir, in the discharges from dye works you have, practically speaking, two kinds of discharges ; you have the discharges from dye vats after the liquids there are spent, and they have exhausted the colour as much as they may ; or, when they are changing from one colour to another as they often do the vat has to be discharged, so as to enable them to make up the new colour. There is that discharge, but there is also the much larger discharge of waters that are used for cooling the goods after they have been dyed, or washing off excess of dye. Now, these latter waters are not very grossly polluting. They do carry with them a considerable proportion of suspended matter, but there is a very large amount of water, and it is these waters that I would suggest it would pay every dyer, who uses town water, to recover, to purify, and to use up in his processes again.

28368. Would you suggest that even in cases where there is possibility of connection to sewers ?—I would where they use town water. You see, Sir, they pay—I suppose the minimum payment for town's water would be something like 6d. a thousand gallons. Now to purify these waters quite sufficiently for use for many of their purposes would cost something like 2d., so there is a considerable profit where a dyer is using 50,000 or 100,000 or 500,000 gallons a day.

28369. But in urban situations the dyer as a rule has very little spare ground, and if he has any he desires rather to keep it for the extension of his business than for the purification of his effluent ?—That may decide him, but such apparatus as these which I have described —there is Waite's and Mackey s and Bell's apparatus—take up very little room.

28370. Then in cases where there is room you suggest that the re-use of the waters is at once valuable to the business and is also of course valuable in reducing the volume of what is turned out ?—That is so.

28371. (*Sir William Ramsay.*) Could you give us some idea of the process ; is it precipitation with alumino ferric or alumina ?—Yes.

28372. (*Chairman.*) I was going to ask you a little later about Waite's apparatus, but it might be convenient to deal with it here. Would you explain to us briefly and generally what is the character of that apparatus ? It is, I take it, the chemical precipitation in vertical towers ?—That is so.

28373. And in the case which you describe you have three towers, each 30 feet in height and about 7 feet in diameter ?—Yes, Sir.

28374. And the flow is upward through all three ?—Always upward.

28375. So that you have chemical precipitation in a tank 7 feet in diameter and 90 feet deep ?—That is so, with a rising flow. No, Sir, that is not quite so, because what goes through the first tower is divided between the second two.

28376. Then it is 60 feet ?—Sixty feet.

28377. The one you describe is 30 feet deep ; one tower is 8 feet by 30 feet, and the other two are 7 feet by 30 feet ?—Yes, that is so.

28378. I thought the flow was from one to the other ? —The flow from the first tower is divided between the second two ; 60 feet.

28379. So that it really is a 60 feet tank ?—It amounts to that.

28380. And do you find that this form of settlement is not only valuable as occupying little space, but is exceedingly effective in the way of separating the suspended matter ?—It is very effective indeed, and if you look at the final effluents, the amount of suspended matter that is left is sometimes so small as to be negligible. I think I may say when it is marked very small in these tables it means that there must have been certainly not two parts per 100,000, which is excellent for a settlement of that kind.

28381. Then this apparatus you suggest would be of interest to the Commission, quite apart from the purpose to which it is applied in this case ; you suggest probably that in many cases where there is not much room an apparatus of this kind would form a very effective method of settlement ?—I do. It is a very effective apparatus ; one of the best we have.

28382. And in this particular case the use of it permits the effluent to be re-used on the works ?—Yes.

28383. (*Sir William Ramsay.*) May I put a question as regards that ? Does not the presence of sulphate of alumina interfere with the use of the water afterwards, or is the sulphate of alumina always precipitated by the dye ?—I think it is all precipitated practically. I am afraid I have not any detailed analysis to find out how much remains, but at least I may say this, that the effluent after treatment can be used up by the dyer even by itself in his dye house. That you must bear in mind is for certain kinds of dyeing ; it would never do for dyeing faint shades on white goods, but for black dyeing of such goods as they deal with in the Batley neighbourhood it does very well. You will see the effluents are still somewhat hard, but as a matter of fact they are not any harder than the natural stream water in that instance.

28384. (*Mr. Tatton.*) Is the colour removed at all by this apparatus ?—The effluent has a pale straw colour.

28385. Is the dye water black ?—Oh all colours ; blue, black, red sometimes ; it varies according to the discharges from the dye-house.

28386. Do they use logwood at all at the works, do you know ?—They used to.

28387. (*Sir William Ramsay.*) Is not Logwood tincture used now ?—They very frequently now use logwood in bags. I believe they do use some logwood. They have aniline dyeing I can remember quite well, and they have what we call burl dyeing, which is pretty much of the same kind as logwood. They use a wood extract and iron to dye cotton in the other goods black.

28388. (*Mr. Tatton.*) Yes, to what do you attribute the removal of the colouring matter ; to what process or what apparatus ?—Oh, to the precipitation and the removal of all the suspended solids that the precipitant produces.

28389. If the same precipitant were used in ordinary tanks would you expect the colour to be removed in the same way ?—Yes, in effective tanks. I do not think the apparatus has anything to do with the removal of the colour except in the removal of the solids.

28390. It is simply a convenient way of dealing with it on a small space ?—That is so.

28391. (*Chairman.*) It may be well for us to note in the evidence that the cost of the apparatus which you describe in your interesting pamphlet is in this case about £750 ?—Yes.

28392. And that the cost of working it is stated as £1 6s. 6d. per week ?—Yes.

28393. And that the volume it deals with is normally 30,000 gallons, but that the apparatus has been at times used up to 50,000 gallons a day ?—Those are the figures given by the manufacturer.

28394. Well, now returning generally to the question of dye waters, what are the special characteristics connected with indigo dye waste effluents ?—In the mills with with which I am acquainted the discharges from such premises are again rather threefold. Indigo dye vats are made up and used for long periods at a time, six months, sometimes longer, but in the end the contents of the vats become dirty because of the goods that have been passed through them, and have to be discharged, and that discharge from an indigo vat is very polluting. In most cases they remove the liquid from the vat into a fresh vat, and leave a very offensive putrid sludge, because one part of the indigo process is, in certain classes of indigo vats, to produce a sort of putrefaction of the vat contents, so as to dissolve the indigo, which only dissolves in the absence of oxygen, and the putrefaction deprives the liquid of oxygen. That is the most polluting class of the refuse, but fortunately it is not very great in quantity, because as I say these vats are only emptied at long intervals. Then when the goods are taken out of the vats, the excess dye has to be washed out of them, and that is washed out in considerable volumes of water. This carries with it a great deal of indigo, and very frequenly Fuller's earth is used to remove the indigo, so that you get a liquid with a considerable amount of matter in suspension. The indigo in that case has become oxidised, and is insoluble. Then there is a further amount of water as the washing is continued, which is quite clean water. The goods are washed off until the water is quite clean ; that is, it is gradually getting cleaner. Well now, the first part by itself, the discharge from the dye vats, would be a liquid exceedingly difficult of purification, very difficult indeed, and as a matter of fact I do not think there is any necessity for them to discharge that ; the liquid part of the vats gets removed to other vats ; the solid sludge in the bottom ought to be dealt with as solids, and not discharged in the refuse, and many of the dyers do so deal with it. The other liquids, especially if they are all mixed together, can be readily purified by settlement. The indigo has become matter in suspension, and settles down along with any Fuller's earth, if that is used, so that the ordinary methods of settlement and filtration should be sufficient in the case of indigo.

28395. But it is essential to keep out this very objectionable form of effluent in indigo works ?—I think so.

28396. And it can be so kept out ?—It can be so kept out. In this case too, Sir, I think it can be done with profit to the manufacturer. Mr. Halliwell, who was before you yesterday, I believe, while he was my assistant, went very carefully into this, and I think you have had a copy of a paper by him showing that much of the indigo at least can be recovered from these waste waters. Unfortunately I am afraid I cannot point you to any place in the West Riding where any systematic attempt is made to recover this indigo, but I am confident it can be done, and I believe you will find in Lancashire certain places where it is done.

28397. Has not the supervision and control of waste waters by your Board in many instances led the manufacturer to discover waste in his raw materials for instance, and to his obtaining considerable advantage by giving attention to the matter ?—Oh, yes, very markedly so, and especially in the cases of coal washing and the paper trade ; in other cases as well, incidentally in the re-use of water which formerly he bought from the corporations, and in the recovery of waste products of various kinds. There is one instance, Sir, that you personally will remember ; I got in Mr. Tatton's former district a model of a machine for recovering fibre from the discharges from woollen mills and dye works, and I sent this model round to various manufacturers so that they might see how it worked, and adopt the principle for themselves. One firm in the West Riding has recently, about two years ago, from this model or from works based on it at one of the manufacturers' premises, patented a modification of it, and that is being adopted in many cases with some profit to the manufacturer, and with great good as regards the pollution of the streams, because all the fibre that used to be discharged in their trade refuse rendered it rather more difficult to purify their trade refuse, and often did escape into the streams. Now, they find by the use of this machine, which is practically automatic in working, that they can recover that fibre, and they do recover it I think, Sir, I would even go so far as to say—although I must say I cannot prove my statement—that if you were to take all that the manufacturers have been forced to do for the purification of the streams, and if against that you were to place all the economy which they have made, the two would nearly balance one another. I am certain you will find it so in the case of the coal washing and the paper trade.

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28398. We are very glad to hear you say that.—And in the case of the recovery of grease.

28399. Now, I would like to ask you generally what effect the action of your Board has had in purifying the streams in the West Riding ; how far has the condition of the rivers improved ?

28400. (*Sir William Ramsay*) From the trade effluent point of view.

28401. (*Chairman.*) The two are necessarily bound up but it is specially from that point of view that we should like to ask Dr. Wilson his opinion ?—I have got some very interesting information on that point. To speak generally, we have frequent observations by the Fishery Board, and by manufacturers who are using the water, by workmen who pass the streams daily, and others, that the larger rivers are very much improved. The improvement in the larger rivers is, however, rather hidden, because, I am sorry to say, the Board has not yet dealt effectively with the pollutions from the large towns.

28402. You mean the pollution by the local authorities themselves ?—Yes.

28403. In the form of sewage mixed with trade effluent ?—That is so, but the effect of the Board's work on the smaller streams is very marked in many cases. Some of these smaller streams that used to be filthy sewers—you could not call it water that was running down them ; it was as bad as any town sewage—some of these smaller streams are now totally changed. On the other hand, I must say that, especially in connection with the pollutions by gas liquor, some of the small streams that formerly were clean are worse, because one colliery established on a small stream will wholly spoil it. I can give you a case very much to the point there.

28404. And there is, I suppose, large development in your district of coke ovens ?—Yes, I think there are twenty-three now, and there was only one ten years ago. I can give you a case, Sir, very much to the point. A colliery was opened on a small stream, which was a source of supply for the Borough of Rotherham, and before this colliery was opened the company was warned that polluting liquids were likely to be discharged, and that they must take steps to purify those liquids before they were discharged. Well, they said that they would take such steps. They opened the colliery and they established the processes of coal washing and making of coke in patent ovens, with the accompanying discharge of chemical refuse. They adopted certain measures, chiefly settling tanks, for dealing with their trade refuse, but the discharges were grossly polluting even after that little

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treatment, and are at the present time; that has gone on for some years now. They have been cited before the Rivers Board, and have undertaken to do certain works, but about a year ago the Rivers Board were obliged to apply to the Local Government Board for leave to take proceedings. As you heard the day before yesterday, we have not had any reply from the Local Government Board on that case, and the Rotherham Corporation has felt itself bound to apply for an injunction against the company, because of this pollution of one of their sources of water supply. That is one of the instances of what was absolutely a clean stream of drinking water being foully polluted by a new discharge, and the present powers of the Rivers Board are not sufficient to prevent such cases.

28405. And do you say that this stream is part of the Rotherham water supply?—Yes, Sir; they have had, of course, to cut it off. May I say, Sir, it is perhaps apart from this kind of evidence, but I feel very strongly that if any new legislation on such questions is promoted, it should include some provision for absolutely preventing the establishment of any polluting discharge on certain streams, and in all cases it should include power of preventing the establishment of any polluting process on a stream unless the manufacturer will previously show that he is adopting the best known means for preventing pollution. It is clearly ridiculous that the Rivers Board, that any sanitary authority, should be in the position of having to deal with an absolutely new pollution in the same way as an old pollution, and, as a matter of fact, of waiting until the pollution is set up before their eyes.

28406. Mr. Atter suggested that, in the case of a manufactory being established which is likely to produce any effluent at all, he would lay it down that notice should be given to the Rivers Board that a person proposed to commence that business?—And to the sanitary authority.

28407. And to the sanitary authority?—To both, Sir, I think.

28408. And to satisfy them that the means he proposes to take are such as probably would prevent the pollution or reduce it to a negligible amount?—Yes, Sir. And I would suggest that either the Rivers Board or the sanitary authority should have the power of forbidding the establishment of such a source of pollution, with an appeal to a central authority. They have that power in Germany.

28409. The forbidding of the establishment of the business in a particular place would be a rare occurrence, would it not?—Oh, very rare.

28410. You mean, at certain heads of streams, or on streams where waters are used for drinking purposes; cases of that kind?—Yes; and there would always be an appeal to a central authority. You know, Sir, that it would always be to the interest of a sanitary authority to have a new industry established within its borders, and it would be a very rare thing indeed for the Rivers Board to object to the establishment of any such industry if the manufacturer establishing it were prepared to deal with his polluting refuse in the best practicable way.

28411. (*Sir William Ramsay.*) In fact, you prefer to lock the door before the steed is stolen, rather than after?—You may imagine how aggravating it is to see one of those very bad pollutions established without being able to say a word to prevent it, or to do anything to prevent it.

28412. (*Chairman.*) Until the pollution arises?—Until the pollution arises.

28413. And then you are involved in very considerable delays before you can take effective action?—I do not suppose we can touch any such manufacturer in less than a year, and, as at present, we do not know how many years.

28414. (*The Secretary.*) May I draw attention to the case in which a manufacturer wishes to establish some quite novel process. In such a case, the Rivers Board would have no experience to guide them as to what would be a satisfactory method of dealing with the refuse from such a process, and would they not be taking upon themselves serious responsibility by either approving or disapproving works of purification suggested by the manufacturer. That such a case may arise is shown by the fact that even to-day it is not known how the gas liquors from the coking plants, which have been established, may be purified. The alternative plan of saying to the manufacturer that the refuse must be purified up to a particular standard and leaving to him the responsibility of designing his plant so as to attain to that standard seems to have more to recommend it.

28415. (*Sir William Ramsay.*) Do you not think that another view of the case is possible? That is, that it would be very rare that a totally new industry is started. If you take that case of coke distillation, it is practised in a good many other parts of the country, and there will be or are means of purifying the foul effluents?—And it is the same liquor that has been discharged for many, many years from gas works. And may I add that if a man does establish a new industry, even if this had been a completely new industry, the responsibility surely rests upon him for the effective purification of his refuse if he is going to discharge that refuse into the stream. If it cannot be purified, then he must remove his works elsewhere; take them to the seaside.

28416. (*The Secretary.*) If he has submitted plans which you have approved of, and afterwards he has worked those plans perfectly so far as they can be worked, you have approved those plans; he has brought to the use of those plans the most efficient management possible; surely the Rivers Board that approved them could not shift the responsibility in such a case?—I think the Rivers Board should be prepared to take such responsibility, and if not the Rivers Board, the central authority.

28417. What I feel is this; in the cases of works, the refuse from which we know very well how to purify, if the manufacturer has express notice that there is that standard on that particular reach of water and it is very well known in the trade how that can be achieved, there is no need to do anything more but inflict penalties upon him if he establishes those works and does not achieve that standard.

28418. (*Sir William Ramsay.*) After giving him warning.

28419. (*The Secretary.*) After giving him warning.

28420. (*Sir William Ramsay.*) But almost every case will be covered by such a statement. There might be cases in which a totally new industry is being started?—Yes, quite possible.

28421. Only there is no available means of purification for nothing is known about the waste products; but such cases would be so exceptional that I think it would hardly be worth while to legislate for them.

28422. (*The Secretary.*) If there were that particular scheme that Mr. Atter and Dr. Wilson have suggested in operation, I take it the Rivers Board would have to disapprove because they cannot approve if they have no knowledge; and, therefore that work would never be started in England?—I do not think Mr. Atter suggested, certainly I should not suggest, that such an approval of plans by the Rivers Board or by the central authority, should relieve the manufacturer who adopted these plans from the consequences of discharging polluting liquid into the stream.

28423. It is quite true he did not suggest that, but it seems to me the manufacturer would have very grave ground of complaint if he puts up what you have approved of, and he works it in a perfect manner?—If it were a perfectly new industry with a new kind of discharge his plans would certainly only be approved provisionally with a warning that there might be a polluting discharge from them.

28424. What do you gain by approving the plans at all beyond what you get if you simply told him: "You have to achieve that standard on that reach of water and if you do not you will be subject to severe penalties." Why do you want to come in and see his plant at all?—That is another way of dealing with it.

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28425. (*Chairman.*) Is not that really much the simpler way ?—I do not think so.

28426. (*The Secretary.*) You would remove all the responsibility in that way ?—I do not think so.

28427. (*Chairman.*) A person establishing a business on a river gives you notice that he is so establishing it, and receives from you the information that he must purify his effluent. He is pretty sure to ask you : " What do you expect me to do ? "—Yes ; as a matter of fact they do unofficially do that at present.

28428. Well, Mr. Willis suggests you should simply say : " We expect you to turn an effluent into the stream which would be within the limits of this standard for this stream."

28429. (*Sir William Ramsay.*) But if the relations are established which we hope there will be, there would be no difficulty in getting that man to do as much as was shown to be done in other cases.

28430. (*Secretary.*) What I thought was suggested was to put this in the Act of Parliament, that he would submit plans to the Rivers Board before establishing works, and that they shall either approve or disapprove them ; if they disapprove them, then he shall not put them up at all. It seemed to me that there are very great objections to that form of legislation.

28431. (*Sir William Ramsay.*) Yes, that is quite right.

28432. (*Mr. Tatton.*) I think we have yet another case ; supposing a man wishes to establish a dye works on, say, not a drinking-water stream, but a clean stream ; he purifies his waste as much as he possibly can and yet turns out a highly coloured effluent ; innocuous discolouration ; are you to allow that on an otherwise clean stream ?—Personally I should not, unless there was such a large volume that the stream would deal with it very shortly.

28433. I am supposing a stream that will be highly coloured for miles down ?—Personally I should not, but I think, Sir, someone must take the responsibility. The manufacturer should not be able to release himself from his responsibility, whatever works he puts up. But in such a case as has been suggested, it seems to me that at any rate the Central Authority might very well take the responsibility of saying whether such and such works were in their opinion likely to give a good result.

28434. (*Sir William Ramsay.*) Purification works, you mean ?—Purification works.

28435. (*Chairman.*) So that what the Rivers Board would do would be to refer the manufacturer, proposing to start a business, to places where satisfactory arrangements were carried out ?—Yes. And, Sir, I should go further in such a case as that I have mentioned at Rotherham, where a manufactory was to be established on a drinking-water stream, and a manufactory which was certain to produce polluting effluents ; someone should have the power of forbidding it.

28436. Or what is equivalent to the same thing, of making a much more stringent standard in such a case ?—Yes.

28437. (*Sir William Ramsay.*) Which would come to the same thing ?—Which would come to the same thing.

28438. (*Secretary.*) In that particular case could not Rotherham have gone to get an injunction when they found these works were to be established, to stop the establishment ?—I do not know ; I suggested that to them.

28439. (*Sir William Ramsay.*) It appears to me that if our recommendation is adopted, that the Central Board shall have charge of the water supply of the district, that they will see to this.

28440. (*Secretary.*) Not take charge, but have a watching interest.

28441. (*Sir William Ramsay.*) A watching interest.

28442. (*Secretary.*) It is not proposed that they should have charge of it.

28443. (*Sir William Ramsay.*) If they have a watching interest they should have power to see to that ; someone should have power to see to that.

28444. (*Secretary.*) The court has power.

28445. (*Sir William Ramsay.*) The court has power, but then it would be too late.

28446. (*Secretary.*) I think they could have moved at once ?—The court has no such power at the instance of a Rivers Board.

28447. The Corporation of Rotherham ?—That is a private owner. In that case the private owner naturally objects to paying for a Rivers Board to guard the purity of the streams, and having himself to take action.

28448. It is a very exceptional case.

28449. (*Sir William Ramsay.*) Might I put this question of a general character ? I should like to know whether there is any objection on the part of members of the Committee of your Rivers Board to take action. Does the Committee consist in any part of persons willing to adopt the policy of *laissez-faire* ?—No, Sir, not at all ; I do not think any of them ; they are all very zealous as far as I know them.

28450. Are they personally interested ; are they manufacturers who act as it were against themselves, or against their set ?—That is so ; a considerable proportion of them are manufacturers, or are interested in manufacturing.

28451. But there is no difficulty ?—No, Sir ; none. With your permission I should like to say something more about the improvement of the streams.

28452. (*Chairman.*) You had not finished what you had to say about the improvement of the streams ?—I have here, Sir, a number of extracts from the Reports of the Yorkshire Fishery Board. In 1898 they said " the pollution of the Aire has much decreased." In 1900 : " Pollution is diminishing in the West Riding ; there is a reappearance of salmon in the upper rivers." In 1903 : " Salmon are seen in tributaries of the Ouse, where they have not been seen previously for many years." In 1904 : " The polluted waters from the West Riding are nothing like so bad as they were some years ago," and so on ; that still goes on. Then with regard to the smaller streams, there are certain streams in the West Riding where pollutions were very bad formerly, (and this is a reply to the question Mr. Tatton put to me) and are now greatly improved. The River Worth, which was grossly polluted with wool-washing refuse, is wonderfully changed, so changed that small fish are returning to it and kingfishers are seen on its bank now. The same applies to the Carr Brook, a tributary of the Calder, and I have one very interesting report that I only got last week. In the Royal Commission's Report of 1867 on the Calder, they stated that no fish had been seen in the Calder at Wakefield since 1857. Now, Sir, my district inspector has reported to me that Mr. George Thompson, the lock-keeper at Bankdole Lock, on the Aire, just below the junction with the Calder, informs him that since 1908 he has frequently seen both pike and roach in the river and canal, near Knottingley, and has caught one pike and three roach in the canal, and one roach and an eel in the river. He gives the weight of the various fish, but that is not important. Then, Sir, I wrote to the Aire and Calder Navigation, asking them whether they found any difference in the amount of sludge which they dredged from the river, and I have the following reply : " I have now pleasure in enclosing you two returns of the dredgings comprising the periods mentioned in your letter," that is in the years 1891 to 1893 inclusive, and again in the years 1906 to 1908 inclusive. I would hand in these if I may.

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COMPARATIVE STATEMENT of MATERIAL DREDGED from the Navigation between WAKEFIELD AND CASTLEFORD during the years 1891 to 1893 and 1906 to 1908 respectively.

Year.	Description of Material.						Totals.
	Mud.	Silt, etc.	Silt and Ashes.	Sand and Ashes	Gravel, etc.	Refuse.	
	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards
Years 1891 *to* 1893 :—							
1891 - - - -	8,195	2,872	7,581	1,333	145	—	20,127
1892 - - - -	1,613	—	1,070	5,005	2,537	10,818	21,043
1893 - - - -	1,548	3,397	567	2,793	189	—	8,494
Total - -	11,356	6,269	9,219	9,131	2,871	10,818	49,664
Average of 3 years -	3,785	2,089	3,073	3,044	957	3,606	16,554
Years 1906 *to* 1908 :—							
1906 - - - -	1,054	—	—	—	—	—	1,054
1907 - - - -	11,749	—	1,626	187	—	—	13,562
1908 - - - -	2,152	1,726	225	796	—	—	4,899
Total - -	14,955	1,726	1,851	983	—	—	19,515
Average of 3 years -	4,985	575	617	328	—	—	6,505

LEEDS,
23rd *January*, 1909.

AIRE AND CALDER NAVIGATION.

COMPARATIVE STATEMENT of MATERIAL DREDGED from the Navigation between LEEDS AND CASTLEFORD during the years 1891 to 1893 and 1906 to 1908 respectively.

Year.	Description of Material.						Totals.
	Mud.	Silt, etc.	Silt and Ashes.	Sand, etc.	Gravel, etc.	Refuge.	
	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards
Years 1891 *to* 1893 :—							
1891 - - -	6,563	1,298	4,014	184	—	—	12,059
1892 - - -	8,676	3,286	3,740	37	1,700	3,039	20,478
1893 - - -	4,191	2,265	1,510	—	1,589	—	9,555
Total - -	19,430	6,849	9,264	221	3,289	3,039	42,092
Average of 3 years	6,477	2,283	3,088	74	1,096	1,013	14,031
Years 1906 *to* 1908 :—							
1906 - - -	12,801	790	—	—	301	—	13,892
1907 - - -	7,911	1,880	—	37	226	—	10,054
1908 - -	4,425	4,481	—	—	—	—	8,906
Total - -	25,137	7,151	—	37	527	—	32,852
Average of 3 years	8,379	2,383	—	12	176	—	10,950

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23rd *January*, 1909

To sum up, in the average of the first three years between Wakefield and Castleford, on the River Calder, there were 16,554 cube yards of mud, sand, etc., dredged from the river, not only from the river but from the small portions of canal that go from bend to bend of the river, in some places. In the later period in the same place there were only dredged 6,505, that is a little more than one-third. And from the River Aire, between Leeds and Castleford, and from the canal cuts in that stretch, in the first period 14,031 cube yards were dredged and in the second period 10,950. Now, Sir, the difference there is not so marked because during both periods all the sewage of Leeds was being discharged into the river with very little treatment. But the state of matters there is recently very greatly changed. This is a return that I have obtained from the sewage engineer of Leeds, and now for some months past at their Knostrop Sewage Works, in a week they are removing from the sewage 42 tons of screenings, 469,000 gallons of liquid sewage, which makes 646 tons of sludge cake, and dealing with 145,500,000 gallons of sewage.

28453. You say they are removing these amounts; do you mean per week, per day, or what ?—That is in a week.

28454. Per week ?—Per week. That will make an enormous difference in the river.

28455. Yes. That has only come into operation within a few months ?—Yes, within the last six months.

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28456. It is not embraced in the period before us before ?—No, that is why I say there will be a further reduction.

28457. Will you tell me when the settlement of Bradford sewage first became effective ?—I forget the exact year ; it is about three years ago. Three years ago they began to treat the whole of their dry weather flow by precipitation and settlement.

28458. Then do you know what they would draw from their sewage ?—No, I am afraid I have not that figure.

28459. Because I am rather surprised to find that the difference in the dredgings should only have fallen from 14,000 to 10,000 cube yards, in view of the fact that the Corporation of Bradford had within the second period carried out the settlement of suspended matter ?—I do not think that is very surprising, Sir, because of the solids that were discharged from the sewage works of Bradford a great proportion settled in that stretch of river between Bradford and Leeds and that is not a part that is dredged by the Aire and Calder Navigation. The solids settled there and in times of flood were washed out and away beyond the stretch to which I have referred.

28460. Then that would probably be the explanation ?—I think so, Sir.

28461. That they settled on the way before the Aire and Calder have to deal with them ?—Yes.

28462. Are you able to tell us from other data whether the condition of the Aire between Bradford and Leeds has been improved by the treatment of Bradford sewage ?—I have constant reports from my inspectors Sir, and from my own observation I know the greatly improved state of the river there and I have here, for what it is worth, a newspaper article of May 22nd, last in a Bradford paper : "A great change has come over the condition of the river during the last twelve months."

28463-4. Are you now speaking of the portion of the river between Bradford and Leeds ?—I am speaking more particularly of the length between Thackley and The Ten Arches. That is that portion below Bradford. "A smell from the river is the exception rather than the rule, and the appearance of the water itself is vastly improved."

28465. That they think it is sufficient ?—No, I think not ; I do not think anyone will go so far as to say that.

28466. (*Chairman.*) There is this to be said in regard to the improvement of rivers under the conditions at all events below Bradford, that immediate improvement cannot be expected from any change of treatment ; that the whole bed of the river is covered for many feet thick with matter which will take a long time to be removed, and there immediate change is scarcely to be expected ?—I do not think so, Sir. That has often been put to me. I believe myself that the floods of one winter would clean out the bed of the river. I say that for this reason. I have often particularly observed, both the Aire and the Calder after two or three days holiday ; I noticed the Aire especially after last Christmas holidays when the mills were stopped for three or four days ; after such a period these streams are to all appearance in their natural state. And there is another thing that leads me to that opinion. They are constantly dredging (partly for navigation purposes, and partly for procuring sand for building purposes), material out of these rivers. It is not really the mud and silt which you would naturally expect, in most cases it is sand, and pretty clean sand at that, where you would expect it to be very filthy, such sand as they can use for building purposes, and do use.

28467. And is such sand withdrawn from the river between Bradford and Leeds ?—I am not sure that I could say that ; I do not think I have seen it done there. It is withdrawn regularly from the River Calder at Wakefield, and I feel certain I have seen it done below Leeds towards Castleford.

28468. Then in short you are able to report to us that largely—no doubt, in consequence of the action of your Board—there is a steady if somewhat slow improvement in the condition of the rivers of the Riding ?—More than that, Sir ; it is my firm belief that if the sewage and trade refuse of these large boroughs were withdrawn from the rivers, especially from the Aire, the rivers would be scarcely recognisable ; instead of being as they are at present so grossly polluted and offensive they would be practically in their natural state ; the River Aire especially. I say that for this reason ; the River Aire down to where the Bradford Beck joins it, is, while still somewhat polluted, so pure that fish live in it, and there are actually fishing clubs that fish down to that point. Then the sewage, partially treated sewage of Bradford, joins it and it becomes as you know very offensive and very polluted. Afterwards it receives the partially treated sewage of Leeds, but all the smaller places on the banks are dealing with their sewage and with their trade refuse more or less effectively, and if these two huge pollutions were taken out I see no reason why the River Aire should not be habitable for fish in all its length, for coarse fish.

28469. And is there any reasonable prospect that within a year or two those two great Corporations will carry out purification works ?—It will be probably more than a year or two. You probably know the position of both authorities. The Bradford Corporation have applied to the Local Government Board for their sanction to a scheme for something like £1,000,000 for the construction of purification works, and I understand that the sanction of the Board, if not already given, is just about to be given to that scheme. In the case of Leeds they have obtained Parliamentary powers for the purchase of a site for new extended sewage works and they are under an Order of Court to proceed with those sewage works as rapidly as may be. Then, Sir, if you go to the River Calder, the same to a great extent applies to the County Boroughs of Halifax and Huddersfield. Halifax is, under an Order of Court, busy at present constructing a full set of sewage works. Huddersfield is just finishing its sewage works and they are to be opened in the beginning of April, so that in the case of the Calder these gross pollutions will be removed almost immediately. In the case of the Airè, the two huge sewage schemes of course will take several years to carry out.

28470. (*Mr. Tatton.*) And you have orders against these two large Corporations ?—Not against Bradford ; we have against Leeds and Huddersfield.

28471. Have you applied for penalties in those cases ?—Halifax.

28472. Not against Leeds or Bradford ?—No, they have proceeded at Leeds and Bradford in such a way that the Rivers Board did not think themselves justified in applying for penalties against them.

28473. (*Chairman.*) Then you have reason to look forward to a very considerable improvement in the rivers in the West Riding in the course of a few years when these schemes are carried out ?—Enormous improvement.

28474. When these schemes are carried out, not only will they remove the domestic sewage from the stream but they will remove the worst part of the trade effluents ?—That is so.

28475. From these urban districts ?—That is so.

28476. In our study of this matter what do you think would be the directions we should best work in. Your Board and similar bodies on the Mersey and Irwell and on the Ribble have carried out a great deal of very valuable work, the results of which have been put before us. Would it not be best for us to confine our attention, at all events at first, to those cases where special difficulty has been found in bringing about good results from bad effluents ?—I think it would, Sir ; it would certainly be of most service to the manufacturers and to the Rivers Boards and county councils.

28477. Well, what are the directions in which you suggest that we might properly work ?—I would suggest Sir, that one of the first kinds of pollution that you should investigate should be that of the spent gas liquor, because it is, in its present form, comparatively new and it is rapidly increasing, and it presents, has presented at any rate, to the manufacturers, very considerable difficulties, although I believe that good methods of dealing with such liquor are being evolved and that they will be able to be dealt with without any great cost to the manufacturers, but up till now certainly the question has presented very great difficulties.

28478. What is the next ?—Then in the West Riding, of course, the great thing is the woollen trade in its various branches, wool washing, piece scouring and dyeing. I do not very well see how you can deal with

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them separately, because they are almost always found in conjunction in single premises. The brewing and the paper making discharges are, I think, probably the most general pollutions throughout the whole country and certainly they affect the West Riding very considerably.

28479. Inasmuch as there is a much larger development of paper making outside the West Riding; the same remark applies to brewing; we may best study those not within your area but elsewhere ?—I believe so.

28480. So you suggest to us within your area we might confine our attention, at present at all events, to the gas liquor effluents and to the woollen trade effluents ?—That is so; and in connection with the gas liquor you might very well take up the question of coal washing refuse, because in every place where they have these patent coke ovens they have coal washing. I do not think that will take up much of your time.

28481. We might see that incidentally ?—Incidentally.

28482. In regard to the best places for us to visit perhaps it is unnecessary for me to ask you that at this stage; you would probably be good enough to consider a small itinerary for us so that we might, without spending too much time, visit typical places ?—I should be very glad to do that. I am sure my Board would put its officers at your service in the West Riding.

28483. For information of that kind ?—For information of that kind; and I am sure the manufacturers would give you all possible information; they have been most kind.

28484. Perhaps it would be advisable for us to visit the places alone, without any of the officials of your Board ?—I think it might, but I do not think they would object at all; perhaps the Commission might ask them; some of them would prefer I should be there but some of them might not.

28485. I am quite sure your personal assistance would be of great value to us, but I was rather wondering if manufacturers might speak more freely to us if their immediate supervisors were not present ?—In the great majority of cases it would not be so, but there might be cases where they would, and if I might suggest it, the Commission should ask the manufacturers beforehand whether they prefer that I should not be present. May I put this view, Sir, before you ? I am glad to hear that you speak of visiting those places, I feel so strongly that it would be impossible for the Commission to understand these various processes and the effluents that come from them unless they can see the processes at work, and I am sure that the manufacturers will welcome the Commission and will give them all the information that they can.

28486. We quite appreciate the necessity of that, and it will also give us the opportunity of coming into contact with the manufacturers themselves who may wish to put their view before us; we should like to give them the opportunity of doing so ?—Yes.

28487. (*Mr. Tatton.*) With regard to the improvement in the rivers, that has really been brought about in these small streams by the removal of the suspended matter only, practically. I mean to say that the effluents that you get from these woollen scouring works and the piece scouring works are not satisfactory, as far as the dissolved matter is concerned ?—I cannot quite say that because you see in every case, besides the trade refuse that was discharged into the streams there was also a large quantity of sewage which has now been effectively purified. But with reference to the trade refuse alone that is so.

28488. Yes, but you do not find any nuisance from the effluents that you are receiving at the present time ?—From these wool-washing places ?

28489. Yes ?—No; I have been very much surprised at the little effect that an acid effluent from wool washing has produced in the streams. Naturally when it is passing through seak tanks and filter beds it is coming away gradually and in small quantities at a time and therefore it gets mixed with a relatively large volume of stream water and in such circumstances the effect is unnoticeable. And as I said in the case of the River Worth, fish live in the River Worth, which is receiving the acid effluents from a number of woollen mills.

28490. Yes, I see you say that in one of your reports here; this one at Hopton Mills the effluent is discharged into a very small stream ?—There are no fish there for other reasons; there is some ochre water in that stream.

28491. The importance of removing the dissolved matter you say would not be so important as in the case of sewage for instance ?—Generally speaking, no, but in the case of some of these highly organic liquids it must be so.

28492. It strikes me as being very high—your analyses. I wanted to understand why it was that it had not more effect upon the stream ?—That I think is entirely a question of the proportion of the discharge to the stream water. Whether it be in domestic sewage or in trade refuse the matters that give rise to most nuisance are the solid matters.

28493. And the suspended matters ?—And the suspended matters. Either with sewage or trade refuse, if you can thoroughly remove all these suspended matters and have a sufficient volume of stream water to dilute the dissolved matters with, nuisance is little likely to arise.

28494. You have no cases where several works purify and discharge into a small stream that you could judge of ?—Oh, yes, the River Worth especially. I cannot say from memory how many there are, I have not them separately set out here, but there must be, I think, eight or ten trade premises at which wool washing refuse is produced, where it is treated for the recovery of the grease and the effluent is discharged into the River Worth, and yet the effect on the stream is very little noticeable.

28495. Even in summer ?—Even in summer. It is not a perfectly pure stream, but it is so pure that, as I have said small fish are living in it.

28496. (*Chairman.*) I think your view in regard to standards is that your Board and yourself do not favour the fixing of standards. That you prefer the reasonable and practicable limit clause ?—That is so, Sir. I am afraid that even after the Report of the Commission I cannot yet see how it is practicable in the West Riding to fix standards.

28497. I have nothing further to say except to thank you for the evidence that you have given, and to express our appreciation of the readiness with which your Board has put its large experience and information at our disposal ?—Thank you very much.

NINETIETH DAY.

Friday, 26th March, 1909.

PRESENT:

Sir WILLIAM RAMSAY, K.C.B., F.R.S. (*in the chair*).
Sir WILLIAM H. POWER, K.C.B., F.R.S.
Mr. T. J. STAFFORD, C.B., F.R.C.S.I.
Mr. F. J. WILLIS (*Secretary*).

ALSO PRESENT:

Dr. GEORGE McGOWAN.
Mr. C. C. FRYE.
Mr. G. B. KERSHAW.

Mr. HUGH STOWELL, A.M.I.C.E., and Mr. FRANK SCUDDER, F.I.C., F.C.S., called in; and Examined.

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28498. (*Chairman.*) We are much obliged to you for coming here. Perhaps I may put a formal question or two to you, Mr. Stowell, to get it on the Minutes. You are an Associate Member of the Institution of Civil Engineers, and Chief Inspector to the Mersey and Irwell Joint-Committee ?—(*Mr. Stowell.*) I am.

28499. You have held that position since March, 1907 ?—Yes.

28500. Mr. Scudder, I need not ask you any preliminary questions as we have had the pleasure of seeing you here before ?—(*Mr. Scudder.*) Yes.

28501. I think we had agreed to take these documents which you have furnished us with as read, and to have them printed on the Minutes. That is the most convenient way, and then by putting a few questions on them the matter may be elucidated ?—(*Mr. Stowell.*) Quite so.

(*The Witness handed in the following Statement.*)

Including the portion of Derbyshire, but excluding the portion of Yorkshire, which drains into the Mersey Watershed, there are 362 manufactories which have wastes requiring purification before being discharged into the rivers.

The following table gives the number of manufactories in each industry, classifying them as efficient or inefficient:—

Trade.	A.	B.	C.	D.	Total.
	Efficient.	Not efficient.	Purification works under construction.	Treatment not adopted or unnecessary.	
Print Works	25	6	—	—	31
Dye Works	79	18	—	4	101
Bleach Works	67	14	—	1	82
Waste Bleach Works	2	6	—	—	8
Paper Works	20	6	—	—	26
Paper Stainers	2	—	—	—	2
Tanners and Leather Dressers	2	2	—	—	4
Fellmongers	1	3	—	—	4
Woollen Trades	36	8	—	—	44
Silk Trades	1	—	—	—	1
Slack Washing	10	—	—	—	10
Soap Works	1	—	—	1	2
Stone Polishers	5	—	—	—	5
Chemical Works	8	2	—	2	12
Breweries	3	4	—	—	7
Unclassified	13	8	—	2	23
	275	77	—	10	362

The question of the efficiency, or otherwise, of the purification at each works is reconsidered every year, and the decision is based on a general consideration of all circumstances.

Speaking generally, the efficient works are those which can turn out a satisfactory effluent if properly managed

In Class B are included several works which are intercepting solids to the best of their ability, but which are not able, owing to limitation of space, to install an efficient plant.

Class D mainly consists of works which have little or no traceable pollution, newly started works, or works

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from which polluting liquids have occasionally been discharged through carelessness, and which are, therefore, regularly inspected.

Difficult wastes to treat.

Difficult wastes to satisfactorily purify are fellmongers, tanners, breweries, waste bleach works, galvanising works, wood pulp manufacture by the sulphite process.

The difficulty in the first three trades mentioned is mainly one of expense on account of the large filtration capacity necessary to deal with the waste, due to the putrefactive character of the organic matter.

There is only one galvanising works in the watershed from which rivers' pollution has taken place. At the present time the whole of their waste is being taken by a company for recovery processes, but with what success remains to be proved.

The sulphite liquor is a most difficult waste to deal with, and in the only works in the watershed where this process of wood pulp manufacture is carried on the liquor is evaporated. The cost of installing and maintaining the plant is, however, very high.

For other trades in the watershed there are "reasonably practicable and available" means of purification.

Notes on treatment adopted in Watershed.

(a) *General.*—The object aimed at, up to the present, has been the elimination of suspended solids, and such solids in solution as are liable to settle out after short periods of rest.

The treatment usually adopted consists of settlement or precipitation in tanks followed, in many instances, by filtration.

Various recovery processes have been adopted, in certain trades, which have had valuable economical consequences as well as facilitating the subsequent treatment of the waste.

(b) *Print Works and Dye Works.*—Practically all works have provided tanks, and out of a total of 132 works 46 use a precipitant. Filtration of the tank effluent has been adopted in 74 instances. At two printworks the soaping liquors are separately treated, and the greasy matter recovered has a commercial value.

Whether a recovery process is installed or not, the separate treatment of the more concentrated liquors is advisable.

Indigo where used is always recovered for re-use.

At one works in the watershed where copper sulphate is used to resist the fixing of the indigo in indigo-printing, the waste is treated and copper recovered.

(c) *Bleach Works.*—Simple settlement is almost universal, and precipitants are only added at four of the eighty-two works. At thirty works the tank effluent is filtered. The pollution varies greatly with the class of work done, and the chief source of pollution is the "kier" liquor, which is generally discharged in bulk early in the day, thus throwing a large burden on the tanks. At a few works separate tankage is provided for this liquor which is then equalised over the day's flow, and this is very advisable. An increased use of precipitants would probably be advantageous both as regards the finer suspended matter, and also the soluble organic matter. Grease recovery has been suggested, but does not appear to be economically practicable.

Where "finishing" is done, starch waste (which greatly complicates the treatment) should not be allowed to enter the tanks. In most cases separate starch tanks have been provided. The final cleaner wash waters are sometimes separated and may be discharged untreated.

(d) *Waste Bleach Works.*—The waste consists of a very polluting liquor from the boiling of the waste, and a large volume of wash waters sufficiently soiled to need treatment. At two works the polluting liquor has, until recently, been treated separately for the recovery of oil, and undoubtedly this process should be adopted, whether economically successful or not, as a preliminary treatment, followed by precipitation and filtration.

(e) *Paper Works.*—Recovery processes have been generally adopted in this trade. Where esparto-grass is used the caustic liquor is evaporated and soda ash recovered, the wash waters receiving treatment in tanks and filters. The majority of works use wood pulp, and its value has caused the introduction of a variety of "save-alls" and "stuff catchers," so that only the finest fibres escape to the tanks, and these are readily settled if ample tank capacity is provided. In no case is precipitation resorted to, and at ten works out of twenty-six the tank effluent is filtered. The sludge can be, and sometimes is, re-used for the manufacture of brown paper or wrappers.

(f) *Woollen Trades.*—Grease recovery is adopted at the majority of works in the watershed, and should be insisted on as a preliminary treatment. That it is remunerative, even on a small scale, is shown by the fact that contractors provide the acid for the "sap" tanks, make themselves responsible for the treatment, and cart away the "magma" for recovery purposes. The liquor from the sap tanks is highly acid, organically impure, contains finely divided grease, and requires final treatment by precipitation and filtration. Precipitants, other than acid, are used at twenty-one works, and the tank effluent is filtered at forty-one works.

(g) *Slack Washing and Stone Polishing.*—The mineral matters in suspension in these wastes are in every case efficiently dealt with by settlement.

A register is kept giving approximately the amount of trade waste (where ascertainable) at each works in the watershed, together with the method of treatment, capacity of tanks, precipitant used, filtration area, and a note of any recovery processes in operation. A copy can be supplied to the Commission if it is thought necessary.

Suggested useful investigations.

(*a*) Reduction in the polluting nature and quantity of wastes by economy in working and recovery of bye-products. Improved methods of purification will probably follow on these lines, which would have to be initiated by the manufacturer, who would welcome any report of a practical nature which assisted economical working and at the same time facilitated the task of purification.

(*b*) Colour elimination. "Innocuous discolouration" is not an offence, but spoils the appearance of the rivers, and renders the detection of manufacturing pollutions more difficult. This might possibly be arrived at by modifications of the colouring matter employed.

(*c*) The use and value of various precipitants.

(*d*) The filtration of trade effluents by (1) mechanical means; or (2) on biological lines.

Improvement in rivers.

It does not seem possible to produce reliable evidence based on chemical analysis of improvement in the rivers, but there is ample evidence that there has been great and progressive improvement. The appearance and material of the river beds show this, and also the increasing vegetable growth. Mr. Corbett, the Borough Engineer of Salford, in his book on the River Irwell, states that in 1906 he collected specimens of ten flowering plants, mosses, and algæ from the bed of the river five miles north-west of Manchester, and submitted them to Professor Weiss, of the Manchester University, who in his Report says: "The fact that they are on such stones or the rock bed in the Irwell and covered with its water during several months is clear indication that the water has very little poisonous matter in it. I am sure the oxygen is of very little importance in any of these cases."

The improvement is admitted by practically all the manufacturers, and is further evidenced by the continually increasing use of the river water for manufacturing purposes, and by the great reduction and almost total cessation of complaints.

At the present time a large paper mill, constructed on the most modern lines, is nearing completion, which will depend entirely on filtered river water for its supply. It is situated on the River Roch near Bury, and the river above has received effluents from sixty-nine manufactories (twenty-nine wool, nineteen print or dye, seven bleach, four fellmongers, one paper, and nine miscellaneous) in addition to effluents from ten sewage works having a dry weather flow of over five million gallons. At Salford, not far above the commencement of the Manchester Ship Canal, a firm of dyers depend, to a considerable extent, on the water of the River Irwell for their supply, although it has previously received effluents from 250 factories and twenty-eight sewage works.

Standards.

Of the 362 works in the watershed, 146 use, as their source of supply, either partly or altogether, the water of the stream on which the works is situated, after it has previously received effluents from manufactories or sewage works.

There will be great difficulty in fixing practical and acceptable standards for manufacturing effluents. The

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conditions both as regards quality and quantity are so constantly varying (not only in different trades, but also in different works of the same trade), and the ability to construct efficient plants is so complicated by consideration of space available that, if a standard for a trade could be fixed, the exceptions would be so numerous as to resolve itself into the question of what means of purification are "practicable and reasonably available." This is the test which has to be applied under the existing Rivers Pollution Acts, and has resulted in a large measure of purification being achieved, and also allows of further progress in the future.

A fixed standard would have to be a moderate one, and a manufacturer would feel that, having complied with it, he had done all that was required. It would consequently be a difficult and lengthy proceeding to increase the standard. In many cases better results have already been arrived at than could be reasonably expected under a fixed standard. Fixed standards would increase and encourage dilution of the effluent, and a case of this kind can be dealt with on the present lines, but it is difficult to see how it could be provided against with fixed standards.

There is not, in this watershed, any demand by the manufacturers for the fixing of a standard.

Alteration of law.

Such good progress has been made under the existing law that it seems difficult to suggest any radical alteration as urgent, leaving out of consideration the question of admission to sewers. Power should, however, be given to Rivers Boards to institute proceedings for wilful misuse of an efficient plant without first obtaining the consent of the Local Government Board.

DISPOSAL OF TRADE EFFLUENTS WHEN NOT MIXED WITH SEWAGE.

Mr. Frank Scudder, F.I.C., F.C.S., stated :—

I am the chemical adviser to the Mersey and Irwell Joint-Committee, and I have been requested to appear here by the Mersey and Irwell Joint-Committee to describe the chemical portion of the work which the Joint-Committee have been concerned with.

On July 12th, 1898, I gave evidence before you on the disposal of trade effluents when not mixed with sewage. (*See* Vol. II., Evidence, p. 29, *et seq.*).

Subsequent experience has fully confirmed the views that were then advanced as to the procedure that should be adopted by the Joint-Committee for the prevention of pollution of the streams by trade effluents, with the result that good progress has been maintained, and an improved condition of the streams brought about. The manufacturers have, on the whole, met the requirements of the Rivers Board in a most conciliatory manner. Not only have additional works of purificaton been created, but those that have proved inefficient have been extended and improved, and what is still of greater importance, in my opinion, is the fact that the manufacturers are fully alive to the advantages of recovering waste products, and of modelling their processes of manufacture so as to minimise the production of trade waste, and it is in this direction that we must look forward for much future advancement.

The result of the work of the Joint-Committee has been a distinct gain to the manufacturer in many ways. Not only has there been an improvement in the condition of the streams enabling the manufacturer to use the water, but by adopting processes of recovery, and carefully attending to the details of the manufacturing processes much saving of raw materials has been effected. Again, the disposal of trade effluent other than into the streams is gaining ground rapidly, and many of the difficult problems that formerly confronted a Rivers Board are gradually disappearing. For instance, esparto liquor from paper works can be kept out of the streams, and in the modern methods of mercerising cloth (an important industry), involving the use of caustic soda, there are several processes available for recovering the soda, and in instances where the installation of a recovery plant is too costly for the advantages to be gained, there are simple and effectual contrivances for gaining economy of caustic soda. Again, the sulphite liquor from the manufacture of wood pulp is of a highly polluting character, and it is only comparatively recently that active steps have been taken to dispose of it by evaporation, and that not until economy had been effected in the utilisation and recovery of the sulphurous acid, and the liquor brought into a condition amenable to treatment. There is much work to be done by the trained chemist followed by the mechanical engineer in advancing such methods of trade disposal, and in designing and carrying out economical methods of working for minimising the production of trade waste.

Three of the most important trades, producing trade effluents, that are carried on in the watershed of the Mersey and Irwell, are those of dyeing, calico printing, bleaching and finishing. About 59 per cent. of the works contributing trade effluent to the streams are engaged in the treatment of textile materials, and in these trades the volume of polluted water turned out is an exceedingly large one. About 80 per cent. of the works engaged in these trades have efficient purification works in operation, and 20 per cent. have works constructed, but not efficient.

In dealing with this class of pollution we ask for the removal of the suspended solids, reduction of soluble organic matter, and of all soluble organic solids liable to settle out on standing. The effluent to be neutral in character, and to be as free as possible from colouring matter. The chief organic polluting matters contained in this class of effluent, and which are liable to putrefaction, are derived from the sizing materials used in weaving the yarn, and consist of starches, flour, gums, and fats.

Starch is also employed in the print trade as a vehicle for carrying colour on to the cloth, and also in finishing, and contributes largely to pollution. These substances are to some extent destroyed during the various processes of manufacture, but, as a rule, there is a residuum left sufficient to cause fermentation in the effluent. Greater care is now exercised within the works to minimise the escape of starch, but there is still much room for improvement.

The removal of colouring matter from the effluent is in special cases most difficult to accomplish. Where basic dyes are used no difficulty arises, but with some of the direct dyes where the dyeing baths cannot be exhausted highly coloured effluents are obtained, but the actual amount of colouring matter is very small.

Another important industry in the watershed is that of the woollen trade. There are forty-four works under the jurisdiction of the Joint-Committee. Of these, thirty-six have efficient purification works in operation, and eight have inefficient plants. No difficulty has been experienced in dealing with this class of effluent. Preliminary treatment of the waste for the recovery of oil, followed by chemical treatment and settlement in tanks, and finally filtration through cinder beds renders the trade effluent clear and colourless, and free from suspended solids or liability to deposit solid matter on standing.

As regards the paper-making trade, there are twenty-six works under the jurisdiction of the Joint-Committee. Of these, twenty have efficient purification works in operation, and six have inefficient works. Probably in no other trade has there been so much done in the direction of recovering waste material, and in minimising the escape of solid matter in the effluent with a remunerative result to the manufacturer. As a rule, the purification of the trade effluent is not a difficult one, but in cases where certain raw materials are employed the trade waste is difficult to treat. For instance, where jute is used the kier liquors are of a highly polluting character, and cannot with a reasonable expenditure be rendered innocuous, by any chemical treatment. Coloured rags and old ropeing also yields a bad effluent difficult to purify by chemical treatment. Where pressure has been applied to direct the evaporation of such trade waste, the manufacturer has preferred to give up the use of such raw material.

Waste Bleach Works.—There are only eight works engaged in this industry under the jurisdiction of the Joint-Committee. Of these, two have erected efficient works of purification, and six have inefficient works. It is difficult to secure a satisfactory effluent from this trade waste owing to the high proportion of soluble organic matter in solution, depending upon the quality of raw material employed, and on the processes used for the treatment of the raw material. A great deal of sludge is produced and more efficient purification is required than is at present obtained.

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Fellmongers and Tannery Works.—There are four works engaged in these industries under the jurisdiction of the Joint-Committee. Of these, one only has put down any substantial purification works, and three have inefficient works. The trade effluent is a most difficult one to purify, and the best method of disposal where available is to admit the trade waste into the sewers of the sanitary authorities after preliminary treatment with chemicals and settlement in tanks. The trade waste after septic action, and the removal of the suspended matter, can be discharged into the streams in this watershed without causing any serious deterioration of the water, and it has been observed in the case of the River Beal, which receives the effluents from four fellmongers, that the river is capable of maintaining a large proportion of dissolved oxygen in spite of the polluting character of the discharges from these works, and the standards which are applicable to sewage contamination have to be modified when judging the effects produced by this trade effluent.

Breweries.—There are seven works under the jurisdiction of the Joint-Committee. They contribute, however, a very small volume of effluent to the streams. Three have constructed substantial purification works, and four have inefficient works. The trade effluent is difficult to satisfactorily purify owing to the liability of acid fermentation, and unless a large filtering area be provided, and worked carefully, impure effluents are obtained. The best method for disposal where available is to admit the trade waste into the sewers.

Unclassified Works.—Irregular and small volumes of trade effluent are as a rule produced, and on the whole these works do not materially contribute to the pollution of the streams, but they require constant inspection and supervision.

The Joint-Committee, acting on the advice of Sir Henry Roscoe, their former scientific adviser, have always insisted on the manufacturer using the best practicable and reasonably available means for preventing pollution, and it has not been considered necessary or desirable to fix definite chemical standards. Each case of pollution is treated separately on its own merits.

The legal powers conferred on the Joint-Committee by the Mersey and Irwell Joint-Committee Act, 1892, are, in my opinion, sufficient to deal with any question of pollution that may arise, and the experience gained during the past sixteen years in carrying out the work of the Joint-Committee confirms this view. I therefore, think that the law requires no amendment so far as the disposal of trade effluents into the streams is concerned. It is desirable, however, to extend the provisions of the Act, and undoubtedly similar requirements to those which are exacted in the Mersey and Irwell Watershed ought to be exacted all over the country.

28502. Would it be possible to make a brief statement as regards each trade or kind of works which are found efficient? Perhaps Mr. Scudder will answer it if there is any point he is familiar with?—(*Mr. Scudder.*) I think Mr. Stowell has got that worked out, Sir. (*Mr. Stowell.*) I do not think I quite follow what you mean by the kind of works.

28503. Well, for example, a dye works; what classes of dye works are efficient and what are not? What causes certain dye works to be efficient and others not to be efficient?—I have classified the inefficient works; perhaps it would be as well if I just referred to them.

28504. Yes. Shall we begin with print works?—With the print works. As regards print works, six are shown as inefficient, so that you may say the majority of the works are efficient. Of the six which are inefficient three ought shortly to be efficient as at present they have schemes in hand for improvement. Two of the inefficient works are works which I consider are on the border-line; it is difficult to say that they are efficient, and it is rather difficult to say that they are altogether inefficient; leaving only one works on which it is necessary to put pressure, so that you may say, as regards the print works the probability is that soon they will be more or less efficient.

28505. Now, does that mean that they settle their effluents?—I have given you that, Sir. They all of them have tanks either for simple settlement, or precipitation and I have taken print works and dye works together. In 74 instances out of 132, they filter their tank effluent.

28506. What do they filter them through?—Cinders. I do not think there is any case where there is anything but a cinder filter.

28507. Are any efficient which do not filter?—Oh, yes; you will see there are very few print works which are inefficient.

28508. Yes?—I can give you the list dividing them up between print works and dye works.

28509. How many, for example, of those which are classified as efficient, filter?—That was just what I was getting, Sir. Seventeen of the efficient print works filter their tank effluent.

28510. Supposing we take that as a case, why do the others not filter, and how does it come that their effluent is satisfactory without filtration?—It depends on the work they are doing; the class of printing they are doing; the class of their waste. I do not think in any of these cases where they filter that they have sufficient filtration, but the amount of solids in the wastes varies enormously. I think Mr. Scudder will give you evidence on that point.

28511. Depending on the class of printing done?—(*Mr. Scudder.*) Yes, Sir.

28512. What sort of printing is done where they use alumina salts?—Used as a precipitant?

28513. No; I mean what actually causes the pollution—colouring matter?—No, Sir, soaps. (*Mr. Stowell.*) Gums and the thickenings. (*Mr. Scudder.*) And the thickenings used in the weaving of cloth.

28514. Is there any alumina used to cause precipitation?—No, Sir, alumina is used, but there is not much alumina allowed to escape; the mixing of the bleach croft liquors with the dye waste, causes precipitation. Of course, the use of a filter is advantageous, because it is a safeguard against suspended matter escaping.

28515. Are they streaming filters, or are they tank filters?—Streaming.

28516. I suppose there is no question of nitrification connected with them?—No.

28517. Nothing at all; they receive simply colouring solids?—Colouring solids in suspension, and soluble matter liable to come into suspension.

28518. Would it be possible to give the size of the tanks relative to the volume?—(*Mr. Stowell.*) I can supply the Commission with the tank capacity of the various works and the approximate volume. The volume of waste is very difficult to get at; the manufacturers themselves in a great many cases do not know it, but we have gone into the volume of every works and got it as nearly as we could, and I can supply the Commission with a table showing the approximate amount of waste, the capacity of the tanks, and the area of the filters.

28519. Would it be convenient to you to supply that?—I can supply it. (*Mr. Scudder.*) You would not require the name of the firm?

28520. Oh, no?—(*Mr. Stowell.*) I will give our official number to the firm, and I will supply a key giving the names and addresses of the firms, in case the officers of the Commission wish to make further inquiry.

28521. Send us a statement not for publication?—I will send you a statement not for publication.

28522. Because we might want to go and see the works?—I will send you the names and addresses separately.

28523. We could publish it if we want to?—Yes, omitting names.

28524. Have you any idea what you would consider efficient, and what compared to the total volume?—I should give on that table the classification of the works, whether they were efficient or inefficient in our judgment; the classification which has been adopted by the Joint-Committee.

28525. Thank you. Then after this table comes the sentence: "The question of the efficiency or otherwise of the purification at each works is reconsidered every year, and the decision is based on a general consideration of all the circumstances." When you decide what shall be a satisfactory effluent, do you take into consideration the size and the state of the stream?—I take into consideration the effect on the stream, the reports of my district inspectors, and any samples which have been submitted to Mr. Scudder for analysis.

28526. Of the stream?—No, of the effluent from the works.

28527. Of the waste from the works?—When I say I take into consideration the stream in our inspections, we take into consideration the bed of the stream below the works, but we do not consider the question of the purity or otherwise of the stream.

28528. Have you a special standard for each work; I mean to say, a mental standard, or an idea in your own mind as to what each particular work shall conform to?—(*Mr. Scudder.*) We know in our own mind, but, generally speaking, what we insist on is the removal of the solids in suspension, and a portion of the soluble matter in solution liable to settle out on standing.

28529. Do you put it in figures? Have you any number of parts per 100,000, or is it a sliding scale?—Well, for instance, I do not condemn an effluent if it contains not more than three grains of suspended matter per gallon.

28530. (*Sir William Power.*) That would be a filter effluent?—That is the first standard that they have to comply with, the removal of the suspended matter. If it is below 3 I do not report adversely to the Joint Committee, because there are so many cases where it exceeds 3, and where we are desirous of bringing the manufacturers down to the standard which I have in my own mind, and which I judge by. But you will find by the results, taking the calico print works and the dye works, that they can get well below that, or well within that standard of 3. After good filtration they can remove the whole of the suspended solids. Then we also desire the effluent to be neutral in character; there shall not be any large amount of free alkali or any large amount of free acid.

28531. (*Chairman.*) Then it comes to this, that if the works do not contain more than 3 grains per gallon you do not report them?—I do not report them.

28532. If they are much above that you try to induce them to bring the standard down to 3?—Yes, that is so. Our difficulty now after these years of work is dealing with works that have got only down to 10, and the difficulty of getting them below 10 grains of solids in suspension is very great. Those works which are now classified as unsatisfactory you will find contain about 10 grains of solids in suspension, which is too much.

28533. (*Sir William Power.*) Do you not take account of putrescible organic matter in the refuse in the effluent?—Oh, yes, that would count very much against it.

28534. (*Chairman.*) That would count very much against it?—If the effluent were liable to putrefaction other people would complain about it, and it would be found out.

28535. But putrefaction does not occur in that kind of effluent?—Not in print works refuse. It does not come in except in the case of fellmongers and tanners and people using organic substances, and in the case of bleach works where they employ cloth heavily sized.

28536. (*Sir William Power.*) Then in effect you have another mental standard for them; you have something superadded to the suspended matter and the alkalinity and the acidity?—Yes, but you will find the works which have purification tanks and are efficient works do not produce effluents liable to putrefaction as a rule; if they do there has been negligence with the plant.

28537. (*Mr. Stafford.*) Do all the twenty-five works then come down to that standard of 3 grains?—Yes, Sir. (*Mr. Stowell.*) They can come; they do not invariably do so. If a works has shown that it has purification plant capable of doing it, we call that an efficient works.

28538. But as a matter of fact do they not?—No, I should say they probably do not. (*Mr. Scudder.*) There are periods when the filters begin to get clogged; they want renewing or watching, and that is the value of having the district inspectors. They know when the bed is put in operation, they know when it is likely to cause trouble. They go round, and by their influence they get these filters attended to. If we had no inspectors you would get neglect, and then you would get a bad result. (*Mr. Stowell.*) This is largely a question of supervision; it is somewhat difficult to get manufacturers to attend to their plant sufficiently.

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28539. You would not classify these twenty-three as efficient unless they came down to 3?—If they have proper plant which would enable them to bring it down to that standard they have efficient works, and any inefficiency is caused by carelessness or neglect.

28540. (*Chairman.*) You would not expect in the case of every trade to produce a harmless effluent?—(*Mr. Scudder.*) Yes, Sir.

28541. Then in the case of tanners and fellmongers it can be done?—It can be done, yes, Sir; it is simply a question of expense.

28542. In that case you would use precipitants and ordinary filtration?—And also a septic tank and continuous filtration. You would treat it in the same way as sewage.

28543. With the same results?—With the same results, yes; and there you apply the same standard.

28544. Would you get fellmongers and tanners to go to that expense?—Of course, it is a costly process.

28545. Could you get them to do it?—(*Mr. Stowell.*) We are trying to. (*Mr. Scudder.*) They have filters, but the filters are not worked on biological lines; that is to say, they do not regard them as biological filters, they only act as mere strainers; but we are inducing the fellmongers now to put down proper biological filters.

28546. (*Mr. Stafford.*) You say in seventeen out of twenty-five works there are filters, but with regard to the other works, with regard to the pollution, I do not quite understand how it is that they are classified as efficient when they have got no system of filtration whatever?—They are not classified as efficient, they are inefficient works.

28547. I know; you say seventeen out of twenty-five works have filters, leaving eight which have no filters?—(*Mr. Stowell.*) The probability is that those works are works in which in the waste there is not a large amount of suspended matter to start with, and that suspended matter can be readily settled out without the necessity of filtration.

28548. Without any filtration?—Without any filtration. Personally, I should prefer to have filters at every works after tank treatment, because it is a very good indication to the inspector, as he goes round, how the tanks have been worked. If he has to pass all his tank effluent through a filter, he will very soon find out whether these tanks are filled with sludge and an exceptional amount of suspended matter is going over into the filter. In those works which are classified as efficient and which have no filters, the waste does not necessitate the provision of filters.

28549. The settlement is sufficient?—They can settle out without the provision of filters.

28550. (*Chairman.*) May I ask another question in connection with that? You say it is possible to purify effluents from works belonging to fellmongers and tanners. Of course we grant that, but is it economical; does it put too heavy a tax on the trade?—(*Mr. Scudder.*) No, Sir.

28551. It does not?—No, Sir.

28552. Of course, what you recover is worthless; there is no value in fellmongers' and tanners' refuse?—It is worthless.

28553. But it does not put too heavy a tax on the trade? They can do it?—They can do it.

28554. Mr. Willis suggests, how do you know that they can?—I know they have erected very large tanks but it does not affect their trade. Their trade is still prosperous, and they have put down filters, and renewed those filters, and spent a great deal more money which would have been better spent on constructing biological filters. A thousand pounds spent on a properly constructed filter would probably meet all requirements and such an

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expense would not affect any fell-monger in a large way of business.

28555. (*Mr. Stafford.*) How do you arrive at 3 grains of solids as being sufficient purification? Are you satisfied there would be no loss in the stream?—We have always worked on that, that we have to adopt the best practical and reasonably available means of purifying the waste.

28556. And you are satisfied that will do so?—I would like to see an effluent with no suspended matter; I would like to see a clear brilliant stream. (*Mr. Stowell.*) When we get down to 3, we can then try to get it down lower.

28557. You do not yourself think it quite sufficient?—As a step at present we hope to get them down to 3.

28558. (*Chairman.*) The best practicable means?—That is so; I should not say when we get them down to 3 we will be satisfied and sit down.

28559. (*Mr. Stafford.*) If 3 were sufficient you would not ask them to go further?—When we get them down to 3 the rivers will be so much improved that then we would want them to go more than 3.

28560. You would not ask them to do more than was necessary?—Not more than was necessary.

28561. And if you get them down to 3 it is all you want?—No.

28562. (*Chairman.*) Oh, it is not all you want?—No.

28563. It is a reasonable measure?—It is at present. (*Mr. Scudder.*) A large quantity of material is carried by the streams into the Ship Canal which acts as a large tank accumulating mud deposit and the Canal Company are constantly drawing our attention to these deposits.

28564. (*Mr. Stafford.*) So you think if you had them all down to 3 parts you would still have a nuisance?—I would not say we should still have a nuisance, but it would entail further cost in dredging. I do not think there would be a public nuisance or the creation of a smell, but they ought to be compelled to put in as little solids as possible to avoid dredging in the canal.

28565. (*Chairman.*) We have been informed by Dr. Wilson and Mr. Halliwell that some trades—the paper trade—turn out such enormous volumes of effluent, that the practicability of purifying these very large quantities has not been proved. Have you any experience of that sort?—I have not met that. I know a great many paper works in the country, and I have never come across a paper works yet that cannot turn out a satisfactory effluent, and do it continuously.

28566. That is your experience?—Yes. I could give you illustrations of some of the largest paper works in the country where they have sufficient plant, and they are constantly turning out a good effluent. Of course, in regard to paper works—taking a paper works using wood pulp—that is a very simple matter to deal with. Where you have jute and old rags to deal with you get solid matters there, and they have to have precipitation to remove the soluble organic matter, and filtration.

28567. As regards the filtration of the water before discharge into the river, what is to determine the use of the river in this way? I suppose that the works being on the river, the water has been taken from the river, and they have naturally turned their refuse into the river. But in such cases would sewers not be possible? Is it the fact that because sewers are not available the river is used?—Just so. If you take water from the river for an industrial process you must return it back into the river. (*Mr. Stowell.*) The works below want that water again after you have used it. (*Mr. Scudder.*) If a man has a well then he can apply to the local authority, and he stands a very good chance of being taken into the sewers of that local authority.

28568. It is not because access to the sewers is refused?—Oh, no. Take the case of a manufacturer in Manchester, if the authorities find he is taking water from them they take his refuse into the sewers.

28569. It comes to this, that there is an obligation to return the water to the river?—That is so.

28570. Supposing that is so, does it operate in whole or in part in inducing manufacturers not to turn their effluents into the sewers?—To create manufacturing sewers.

28571. There may be sewers which are suitable, but they are not utilised, because it is absolutely necessary to return the water to the river?—Oh, that is so, Sir, yes.

28572. Then has this discouraged the provision of sewers?—Yes, Sir. In the summer months there is a great deal of worry and anxiety in the Mersey and Irwell Watershed owing to the want of water; the manufacturers will take dirty water in those months rather than go without.

28573. Is this obligation satisfied if the water be returned to the stream at any point, or must it be returned immediately below the works?—No; at any point agreed upon by the riparian owner below. For instance, supposing you have one works situated there (*indicating*), and another works situated there (*indicating*), and this man thinks this man is doing him a slight damage, he may say: "I will take my effluent and pass it immediately after." There are many instances of that being done.

28574. Below?—Below.

28575. That is done?—I know many instances where that is done to satisfy litigation.

28576–77. Now, passing on to the next page, under the note "General," you state that the object aimed at, up to the present, has been the elimination of suspended solids, and such solids in solution as are liable to settle out after short periods of rest. If that is done it is sufficient to prevent injury to the river?—In my opinion it is, Sir.

28578. Is there any radical difference in the kind of bleach works in which filtration is necessary? I should have thought all bleach works were pretty much the same as regards the method of treatment?—It depends on the quality of the cloth they are bleaching.

28579. Does it?—Oh, yes. Take calico printing. Calico printers use a very light cloth. It is not loaded with size and materials, and china clay and magnesium salts; in the calico print trade they use a very light cloth. When you come to pure bleachers there you get cloth heavily-sized.

28580. That is washed out?—That is washed out; you have to wash it out. (*Mr. Stowell.*) I should say there is no trade where the waste varies so much as the bleachers. (*Mr. Scudder.*) In the old process of bleaching they used to steep the cloth in water, and allow it to ferment in order to destroy the starches. Now they have kiers, and treat the cloth with lime and soda, and *vice versa*, preceding the bleaching process. I should also like to add on this point that great improvement has taken place with regard to the sizing of cotton goods. There is a great diminution in the amount of size and filling material used at present compared with what used to be the case when it was in the hands of men who worked by rule of thumb. Now it is done scientifically, and we find the cloth much lighter than it used to be.

28581. Was it not considered a somewhat dishonest practice, to put size in to increase the weight, especially of wool? I know that loading of cloth is complained of?—In the trade they sell a 60-lb. cloth, and take out all the filling so it is a 20-lb. cloth when it is finished, and then they put the 40 lbs. back again before it goes out.

28582. Why is that done?—(*Mr. Stowell.*) That is not dishonesty. (*Mr. Scudder.*) They say it is not fraud. This is asked for. If they did not do that it would have no wear. They do not wash it, it is put on and worn until discarded.

28583. Yes; one cannot account for taste in that respect. Then in these cases what sort of precipitants are used?—(*Mr. Scudder.*) There are really only two main precipitants, lime and copperas, and alumino ferric.

28584. Lime and copperas, and alumino ferric?—Yes. Where the tanks are large they use alumina ferric, and in other cases lime and copperas. Lime and copperas give you as a rule a larger amount of sludge to deal with

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than alumina, but you will find invariably in all the calico print works they use alumina ferric.

28585. Then as regards the woollen trade, the recovery of soap you say is nearly universal ?—Yes.

28586. It is remunerative, is it not ?—Yes.

28587. If it is remunerative, why is it not entirely universal ? Is it that it has not penetrated some of the manufacturers that it pays to recover it ?—I think that is so.

28588. Is the knowledge that it pays spreading rapidly ?—I am afraid it is not making rapid progress because in districts where the wool works are situated they get into the sewers, and by paying a definite sum of money they can let their crude waste direct into the sewer. That is a loss of valuable material. It is a question whether it will ever be recovered at the sewage outfall works at a remunerative price. After it has mixed with the sewage it is expensive and a great deal of trouble. But with regard to the wool-scouring industry I think all the manufacturers should be compelled to recover their grease before it goes into the sewer.

28589. You think a recommendation to that effect should be made ?—(*Mr. Stowell.*) Yes. Whether it pay or not, Sir, they should be made to recover their grease as a preliminary. (*Mr. Scudder.*) In fact, if you go closely into the question you will find there ought not to be any polluting liquid from a wool works ; they ought to recover the grease and the potash salts, and so on.

28590. Mr. Willis reminds me that at Bradford the Corporation prefer to have the grease and everything taken into their sewers ?—You can go to Bradford and see for yourselves and see if the treatment is satisfactory. They get a price, but not so much as if the grease were recovered before mixture with the sewage. It is true that they get sufficient money for the recovered grease to pay for the cost of treating it chemically, but there is an additional burden of expense to be borne in the subsequent process of filtration.

28591. You say : "A register is kept giving approximately the amount of trade waste (where ascertainable), at each works in the watershed, together with the method of treatment." Could you give us a copy of that ?—(*Mr Stowell*). That was the register I proposed to send you of all the works.

28592. I think you have already answered a question which is here—are the rivers now as pure as they need be for manufacturing rivers ; you say no ?—(*Mr. Scudder*). No.

28593. They could always be improved ; at least they might be improved considerably ?—(*Mr. Stowell*). Yes.

28594. And it simply means reducing the total amount of suspended matter and dissolved matter ? —(*Mr. Scudder*). Many of our manufacturers who have to go to the river for the water supply have to filter ; calico printers all those men have to filter the river water, and that is one reason why it is so essential to get the suspended matter removed, because they are able to tell us whether the river is improving or not by the amount of suspended solids which accumulate in their mechanical filter, because the water they use for manufacturing purposes is filtered through mechanical filters of sand and so on—rapid filtering filters.

28595. Then you speak of standards, but I think we have discussed that point sufficiently. You have mental standards which you adjust as time goes on ?—Yes, sir.

28596. And you do not think that it would be unfair to a manufacturer to feel that he never reaches finality ?—Well, it is a limit of impurity that we set, not a standard.

28597. I suppose it greatly depends on the common sense and tact of the inspector not pressing the manufacturer too much at any one time ?—That is so. (*Mr. Stowell*). Working gradually we have had no difficulty ; in fact I may say we have had no request for the fixing of a standard. I have only been two years in my present position, but I have not been asked by a single manufacturer : "What is your standard ; what do you require us to do."

28598. He does not feel after he has put up works that he may be asked to take them down and do something better ?—(*Mr. Scudder.*) No. When they first started they had only tanks ; very few of the manufacturers had filters. Then we advised them to have filtration to check any small amount of suspended matter. It is additional work. I do not think in the whole of our watershed they have had to reconstruct.

28599. Then one or two detailed questions. In paper works, the cost of destroying the sulphite is very great, is it not ?—(*Mr. Stowell.*) Yes, very great.

28600. And I suppose the refuse is no use afterwards ?—(*Mr. Scudder.*) It will be in time. It has been proposed to be used for several things and it is a question of finding a market for the ordinary recovered solids. It has been used for stopping the dust on roads and it is used for glazing paper. Now they are trying experiments in glazing paper. I heard of a man who was going to try a lot in coal pits for keeping down the dust in mines. (*Mr. Stowell.*) It is not a waste material which need be tipped. It has some value.

28601. One other point as regards elimination from the river ; of course, it is not an offence, but you say it spoils the appearance of the stream. What is the standard for that ; have you any impression what the colour ought to be ?—(*Mr. Scudder.*) If we suspend a piece of wool in the effluent it ought not to discolour it.

28602. Is that your present standard ?—(*Mr. Stowell.*) If the inspector goes round and dips a piece of fabric into the effluent and if it distinctly dyes it, it is not innocuous ; if the handkerchief is not affected it is taken as innocuous.

28603. It would, of course, be possible to precipitate many of these colouring matters ?—(*Mr. Scudder*). Yes.

28604. Is there any tendency to do that ?—Oh yes, they all try. They do remove the colour to a large extent. We are not troubled with colour. If we are, we know the manufacturer has solids in suspension. If he removes the solids in suspension the colours drop down to a minimum, except in the case of special dyes. The azo dyes are very difficult to deal with. After being subjected to precipitants the effluent is of a brown colour mostly, but it soon assimilated in the waters of the stream.

28605. I suppose that recovered dyes, except in the case of indigo, are of no use ?—Only indigo recovery. In some of the large works bi-chromate of potash is recovered In some of the large works of course, great progress has been made in the application of colouring matter to fibres. Within the last five years we have had baths which can exhaust the whole of the colour without losing brilliancy in the finished goods.

28606. (*Mr. Stafford.*) I would like to ask about these dye works. There are seventy-nine efficient classified under "A.", and eighteen inefficient classified under "B." ?—(*Mr. Stowell.*) Yes.

28607. Why should certain work be said to be inefficient ?—I have got an analysis here similar to the one I gave as regards print works. As regards five of those works out of the eighteen the space is limited and we have not, up to the present, pressed them to put down further works. The probability is that with the greater efficiency of mechanical filtration we shall in the future.

28608. It is a question of room ?—It is a question of room. Four have schemes in hand for improvement. Three of them are again doubtful. I am unable to say definitely whether they are efficient or inefficient. In some cases we cannot obtain a sample of effluent. Two more are only inefficient when the pump breaks down, but they have been put on the inefficient list because their pumping arrangements are not quite satisfactory.

28609. There is no great difficulty in getting efficiency in these dye works ?—No, no great difficulty whatever.

28610. Is there any great difficulty in connection with bleach works ? You have sixty-seven efficient and fourteen not efficient ?—There will be a great alteration in that trade. A large number of the bleach works in our watershed are in the Bleachers' Association, and there is a considerable amount of reconstruction and redistribution of work, and out of the fourteen bleach works which are at present inefficient eight have schemes for improvement which have been promised and which are on paper,

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and are simply standing over till this redistribution and reorganisation has taken place.

28611. What constitutes inefficiency in connection with bleach works effluent? Is it the kier liquid being so strongly alkaline? What do you insist upon there? Do you insist upon a neutral liquid being discharged into the stream?—(*Mr. Scudder.*) Yes.

28612. You do in all cases?—In all cases, yes, because they can all produce neutral liquid if they will only blend the liquids from the different processes, the lime kiers, with the souring liquids; you have the alkali in the beginning of the process, and the finishing process is acid. Those works that are classified as unsatisfactory are works breaking the standard occasionally; for instance, the discharge of kier liquor untreated.

28613. That is the reason they are not efficient?—That is why they are not efficient; for want of proper methods of mixing the various liquids prior to treatment in tanks.

28614. You say there is no difficulty?—There is no difficulty if they will only put down a few tanks; it is drawing the kiers direct off in the stream which is injurious.

28615. Do all those sixty-seven bleach works that you classify as efficient discharge a neutral effluent?—Yes, Sir.

28616. You insist upon that?—Yes. (*Mr. Stowell.*) They can and ought to discharge a neutral effluent. (*Mr. Scudder.*) We used to say we ought not to have any free chlorine in the effluent in the early days of our work. It is now a most difficult thing to find a trace of any free chlorine going away in any effluent.

28617. Do I understand with regard to the 275 works classified as efficient under "A," that in all those cases you have got a neutral effluent, and you have got also your own mental standard of three parts of solids?—The purification works are such as we agree will produce a satisfactory effluent and comply with our standards.

28618. They have works which are capable of doing that?—Yes, Sir.

28619. And they do it as a rule?—As a rule.

28620. Subject to all you have already said in regard to a certain amount of chlorine and alkali?—Yes, Sir.

28621. Is there any other point you would like to bring before us?—(*Mr. Stowell.*) I do not think I have any other point, Sir.

28622. Coming to paper works, there are six not efficient here. I think Mr. Scudder said it was quite easy to make paper works produce an efficient effluent?—(*Mr. Scudder.*) That is so.

28623. Why should these six not be efficient?—(*Mr. Stowell.*) Well, Sir, out of the six, three have at present works in hand that will probably make them efficient. That is half. One has limited space; I have not been able to suggest how they could extend; and one other has works where the sulphite liquor is evaporated, and which, although greatly improved, one cannot say is efficient yet. There is one which has comparatively recently increased the amount of work, and must improve.

28624. What standards do you apply to these paper works?—(*Mr. Scudder.*) The same standards.

28625. Paper works are works in which you could get a higher standard if you liked to press them?—Yes.

28626. You say it is a very easy thing for paper works to purify their discharges?—Yes. (*Mr. Stowell.*) It is of course economical for a paper manufacturer to get his pulp out, his fibre; if the paper manufacturer turns it into the stream it is a loss to him.

28627. There is a great deal of discolouration in paper works, is there not?—(*Mr. Scudder.*) Yes, when a particular material is used; jute causes discolouration of the stream. They use precipitation followed by filtration. The bulk of the material used in paper works now is wood pulp, and they recover the whole of that.

28628. Do they then discharge a fairly clear liquid?—A very clear liquid from wood pulp works.

28629. From a paper works?—From a paper works, yes.

28630. They do a certain amount of paper staining; but what occurs in ordinary paper works?—(*Mr. Scudder.*) Not in our watershed, but in other parts of the country they use an amount of esparto grass, which produces a reddish brown liquid and where they only use a small amount of esparto they contend it does not pay them to recover the soda, but in all the larger works where they use a large amount of esparto, then the soda is evaporated, and the manufacturer evaporates the whole of the liquor, the kier liquor plus three washings, so that you have practically a discoloured effluent, and that is a great advantage.

28631. Is not that a very expensive process?—Yes, it is; it costs money to work, but we consider it is a cost they ought to go in for.

28632. (*Chairman.*) But does not the value of the recovered soda recoup them for their outlay?—It depends on the market price of soda; it does not pay them very well.

28633. But at all events they do not lose much?—They do not lose much. (*Mr. Stowell.*) As a rule they do not lose much. It about balances, taking one year with another; the cost of the evaporation and the amount recovered. (*Mr. Scudder.*) And the paper makers will admit freely that all that they recover from the appliances which they have introduced into their works has paid them to do it. In the case of wood pulp works, formerly we had effluents with 60 to 70 grains of solids in suspension mainly wood pulp; now there is scarcely any fibre allowed to escape.

28634. (*Mr. Stafford.*) Do they acknowledge that?—Oh yes, Sir, they acknowledge that. It is a business in which you get advances made by the expenditure of sums of money. By putting £200 of recovery plant down you would get a decided improvement. Very well, they did it; they put down filter presses, and all sorts of save-alls inside their works. There is no organised purification plant. The thing is to avoid the production of the waste effluent. If you go round some of these paper works that have put recovery plants down, you will find that they recover the fibre and that it is profitable to do so.

28635. (*Chairman.*) Do the inspectors help the manufacturer in telling him about processes used by other manufacturers?—Oh, no.

28636. They find it out for themselves?—They find it out for themselves.

28637. In urging your case, do you not say to a manufacturer: "Well, Mr. So-and-so up there manages to recover his pulp"?—No, not without permission. I never disclose to another man what I see on a competitor's premises unless it is common knowledge, but I suggest the desirability that he should consider a certain thing and be able to do it himself. He knows as a rule that there are two or three suppliers of machinery and apparatus. He has his own choice. We are in that happy position now. When the first filter came out we were bound by that one engineer's plant. The manufacturer said: "We cannot take on a patented appliance like that." Now we have not to say: "Take that particular thing"; we say there are a variety of appliances on the market, and they can choose for themselves. And it is the same with purification plant. He can have different forms of plant for purification and for recovering. In fact there is a great deal more to be done now by preventing the formation of polluting liquid, and it is to that we must look in the future. That is our future salvation for further improving the conditions of the streams.

28638. And it is gradually penetrating the mind of the manufacturer that it pays to do it on the whole?—Yes.

28639. And not only that, but it saves them a great deal of trouble?—Take calico printers—those who are eminent in their trade. They calculate in their cost sheets and their estimates the cost of treating their trade waste. We can fairly predict for next year what sort of dyes will be used in our watershed different from what we have had before, and we know from the scientific departments how these dyes will work. There are difficulties in the introduction of new colouring matters; the dye may not be quite exhausted. Those in the trade know the whole thing, and of the liability to variation so far as colour is concerned.

28640. They know what is going to happen ?—Yes.

28641. Do you really suggest that there is no problem in Lancashire of trade waste ? That the problem has been solved ; that there need be no difficulty in disposing of trade waste ?—From a Conservancy point of view. Of course, I admit there are many interesting problems to be yet solved. There is plenty of scope for the technical chemist. For instance, take the effluent from a galvanising works. At present we are in this position ; we say we will not permit that in the stream. If a man comes and says : "I will give you a guarantee never to put any more into the stream," then we are satisfied ; that is all right. Now, he has either to evaporate it down, or treat it in such a way that no effluent goes into the stream. There are various methods available for treatment but science has not been exhausted and there is of course plenty of room for new and better methods of treatment, and this observation applies to all forms of trade waste.

28642. Individually, as to how to dispose of effluents, but on the broad lines on which the Commission has to enquire how to purify streams from the excess of trade effluents, you would say there is nothing more to be said about it ; that is done ?—It is done, and there are ways and means known.

28643. (*Mr. Stafford.*) There is no hardship on the manufacturers to ask them to come up to your standard ?—No.

28644. You think not ?—I think not.

28645. Would manufacturers agree with you there ?—(*Mr. Stowell.*) I think so, sir. I think the manufacturers are more and more recognising that what the Joint-Committee are doing they are doing for their benefit. They are more and more using the river water and finding the advantage of being able to get a cheap supply of water.

28646. And in pressing them to do these things, to comply with the standards, you are not driving trade out by putting undue restrictions on your manufacturers ?—Not the slightest. (*Mr. Scudder.*) No manufacturer could come and say we have pressed him unduly in any shape or form, or that he has been a loser by what he has had to do, or that it has affected him in trade. Some of the best manufacturers with the finest works will be found coming here and saying they never regret the day we came upon them, and made them do this. I could give you an instance of a case of one of the largest dye works in Lancashire. There was a dispute with regard to river pollution, and they asked me to go down and report upon it. I had to go accompanied by the solicitor on each side. This was the case of a large dye works where the effluent was going into the river in a very polluted condition. I took my pocket handkerchief and dipped it into the effluent, and withdrew it deeply dyed. I cut it in halves and gave each lawyer a piece, remarking : "That is all I want to do," and went away home. One of the lawyers said that the manufacturer had given instructions to spend any money in defending the case. Of course, there was no defence to that class of pollution. The manufacturer then found out that his managers had not been doing their duty, and he found he was losing hundreds of pounds a year. He only had to reorganise the working of the colour shop and put a stop to the wasteful production of colouring matters which the men discharged into the stream. The colour mixing was at fault.

28647-51. Are all these trades in a very flourishing condition at the present moment ?—Oh, no. (*Mr. Stowell.*) Quite the reverse at the present moment.

28652. (*Chairman.*) I notice nothing is said about tar works, or anything of that sort. Do they not occur in your district ?—We have not a single one discharging into the rivers.

28653. Do they dispose of their refuse otherwise ?—(*Mr. Scudder.*) They all go into the sewers.

28654. I presume they do not take water from any river ?—No.

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28655. Consequently they are not obliged to return anything ?—The tar works are mostly municipal, and belong to the authorities, and they turn all their crude liquors into the sewers.

28656. Any coke ovens for example ?—There are no coke ovens in our watershed ; you have to go to Yorkshire for those.

28657. Dr. McGowan wants me to ask one or two questions. One is in Mr. Scudder's Evidence. Referring to waste bleach works he states : "It is difficult to secure a satisfactory effluent from this trade waste owing to the high proportion of soluble organic matter in solution depending upon the quantity of raw material employed and on the processes used for the treatment of the raw material." What is the nature of that soluble organic matter. Is that what you referred to before, size material ?—No. The manufacturers have been recovering the oil that is in the waste. There is always some fatty acids left behind in the effluents accompanied by secondary products and further purification is difficult to secure. Fortunately there are only a few and they are very small works, but it is a very difficult waste to treat.

28658. Oil is not easily dealt with, I suppose. Is it simply ordinary oil, which you cannot get out ?—You cannot get it out completely.

28659. Then a little further down you refer to fellmongers and tannery works, and to septic tanks being used, then you say the liquor from the septic tanks can be discharged into the streams in this watershed without causing any serious deterioration of the water, and that the River Beal can maintain a large proportion of dissolved oxygen in spite of the polluting character of the discharges from these works. Well, it is not usual to discharge the liquor from septic tanks into a stream without filtration, is it ?—No, Sir.

28660. Is it because there is not enough of it to do any harm ? What is the reason that you suggest that in this particular case the septic tank liquor can be discharged into the stream ?—Well, there is not enough of it.

28661. The stream is so oxygenated that it makes no difference ?—Yes, it makes no difference.

28662. Have you made any experiments to show that septic tank treatment in the case of fellmonger's refuse is preferable to any other form of tank treatment ?—No, Sir.

28663. Is septic tank treatment always adopted ?—Personally, I should prefer chemical precipitation followed by bacterial filters for the simple reason you must get rid of your sludge rapidly to avoid a nuisance. Now, one of the largest fellmongers in our watershed some years ago constructed very large precipitation works ; so large that he had a difficulty in cleansing them. As soon as ever he neglected those tanks solids accumulated and their contents became septic. He did not originally start off with the idea of making them septic tanks, but the sludge accumulated so much and was not removed that they became septic tanks, and decomposition took place in these tanks and it created round the place an awful stench. The effluent stank when it went into the River Beal, but the River Beal is so oxygenated that it is capable of dealing with it. But if I had my way I would insist upon precipitation with constant removal of the accumulated solid matter and then filtration.

28664. Have you any idea of suggesting that he might use filters with his septic tanks ?—This firm is appearing before our Joint-Committee next Tuesday, when we shall press him to give an undertaking to carry out efficient filtration works.

28665. (*Mr. Stafford.*) Just one question. In the last paragraph of Mr. Stowell's *precis*, under the heading "alteration of the law," you say : "Such good progress has been made under the existing law that it seems difficult to suggest any radical alteration as urgent" ?—(*Mr. Stowell.*) Yes.

28666. Well, I take it that merely applies to your own rivers ; you are not making a general statement with regard to the rivers of England ?—It is a statement which applies only to our own watershed.

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28667. You can quite see that there may be a necessity for an alteration of the law in connection with other rivers which are not in such a happy position as yours ?—That is only a suggestion with regard to our rivers. (*Mr. Scudder.*) Working under the Act of 1901; that Act we say would be sufficient.

28668. That Act would be sufficient for the whole country ?—It is sufficient for the Mersey and Irwell Joint-Committee, and I think it would be sufficient for the whole country.

28669. (*Chairman.*) Is there any work or works which you think that the Sewage Commission ought to visit, from this point of view ? We do not want to see satisfactory works. If they are satisfactory it is no business of ours; do you think there is anything we might see in the Mersey and Irwell District which requires improvement, which it would be of use for the Commission to visit ?—You might go and see the fellmonger, Mr. Clegg.

28670. At Rochdale ?—At Rochdale. That is a good case where we want improvement. I think he will do it. If not, we shall have to go for a Local Government Board Inquiry, but as a rule we do not find a Local Government Board Inquiry necessary; they do it. (*Mr. Stowell.*) I would suggest visiting the paper works where the sulphite liquor is treated by evaporation.

28671. But it does not cause a pollution; it is satisfactory ?—As long as the evaporators are at work, but there is an enormous outlay on the tubes, the tubes are eaten away constantly.

28672. They are copper tubes, I presume ?—Copper tubes. There is a large cost to the manufacturer at the present time for renewing his condensers, and he has spent a large sum on those condensers. (*Mr. Scudder.*) You must also remember that fifteen years ago the loss of sulphurous acid came into percentages, the loss of sulphurous acid is now ·1. That is to the advantage of the manufacturer; he solved that problem. For instance, if he turned out liquors containing definite amounts of sulphurous acid it would have been a very difficult thing to evaporate that liquor, but by improving his processes he has reduced the amount of sulphurous acid to ·1 per cent. He then directed his attention to the recovery of this liquor, and went to one of the prominent suppliers of machinery for evaporating, and they made an apparatus, which unfortunately was made of metal on which the liquor acted, so they had to replace all the internal tubes with tin, so that he had a double expenditure, and the whole cost has probably run into thousands of pounds. Now his future is to look forward to make this into a profitable material to recover the cost. It is a progressive work which has been going on for twenty years under scientific supervision. It formerly went into our streams, and polluted those streams very badly for miles down.

28673. Are there any fish in the Mersey and Irwell ?—No. (*Mr. Stowell.*) In the tributaries of the streams there are, but not in our main streams.

28674. It would be impossible for fish to survive at present ?—(*Mr. Scudder.*) Impossible; there is so much sludge.

28675. It is conceivable if purification was a little further advanced, they might come back ?—(*Mr. Stowell.*) The fish are coming back gradually; they have come back to within a mile of the Rochdale Town Hall. And certain up-country streams which have works on them are becoming fishing streams. Kingfishers are returning, which is a sure sign. In the main streams I doubt whether without destroying the manufacturers' rights, you will get fish back.

28676. It is hardly worth fighting for ?—(*Mr. Scudder.*) During the past ten years the transparency of the rivers has improved owing to our action; it is admitted by the public. Ten years ago the transparency of the water was 85 millimeters depth seen through now it is 40 millimetres; and the water, when it is filtered now, has a transparency of 570; the turbidity is due to the small amount of suspended matter. Now the River Irwell only carries 1·2 grains of solids in suspension, while the Irk carries 3 grains. That is our dirtiest stream.

28677. At present ?—At present. The Mersey carries 0·84 grain of solids in suspension.

28678. Of course, that might be natural; it might be the soil that flows through being carried down to some extent ?—Oh, there is no doubt, but when you come to take the quality of the suspended matter you find that that small amount of suspended matter is liable to putrefaction, and this tends to show that it is not the material of the bed of the stream, but that it is derived from pollution. Of course, the manufacturers have done a great deal, and their discharge of polluted effluent into the stream is very slight compared with that from sewage works. We have devoted a great deal of energy, and a great expense has been gone to, to try and purify sewage and yet the organic matter of a putrescible kind is still there, sufficient in amount to be objectionable at times. For instance, these rivers are still liable to putrefaction due to the introduction of unpurified tank effluents. When I go and view these rivers on certain days the condition of the water is very good; the rivers are actually in a state where you think there was a possibility of fish living there; you go again after a storm, and after the storm overflows have come into operation and discharge a tremendous amount of material you get a very different result. Residents round Manchester crossing the bridges have been able to see the sandy bottom of the River Irk, whereas twenty years ago it was 5 or 6 feet deep in mud. Then again, if you take the suspended matter you will find the albuminoid ammonia is largely due to the suspended matter. The albuminoid ammonia in average river water is ·178; if you admit suspended matter, which is of a putrescible character, it is very objectionable; you want to keep it out, and not allow it to go into the Ship Canal.

28679. Perhaps one ought to hear both sides of the question; could you suggest the names of any manufacturers who would give evidence ?—The last time I was here I suggested Mr. King, of Bollington; he is an M.P. for the Knutsford Division, he is a bleacher in a large way and a very capable man.

28680. In regard to breweries ?—(*Mr. Stowell.*) We have none of any importance; all the important breweries go into the sewers.

28681. There is considerable difficulty in dealing with brewery refuse by itself ?—Yes. (*Mr. Scudder.*) They really ought to go into the sewers.

28682. Have you breweries situated away from the sewers ?—(*Mr. Stowell.*) We have one where they have precipitation and double contact, and they are altering their filters at our suggestion, and we hope we shall make them efficient.

28683. You have only four fellmongers in the district ?—That is all; they are reduced in number.

28684. Three are inefficient and one is efficient ?—(*Mr. Scudder.*) That one that was efficient is closed now. (*Mr. Stowell.*) It is doing very little work there, and they have got very large tanks.

28685. Is that an efficient tank process merely ?—And filtration.

28686. And they produce a non-putrescible effluent ?—It is a very small amount of waste compared with Clegg's. (*Mr. Scudder.*) In that case they do not do the same wool scouring, they do not produce the same polluting liquid that they do at the other works. (*Mr. Stowell.*) It is a very much lighter waste at that efficient works.

28687. Do these three fellmongers with non-efficient works agree that it is quite practicable for them to have efficient works ?—I should not like to say they agree that they can put down efficient works, but they are all willing to discuss the question. Two of them are coming before the Joint Committee. (*Mr. Scudder.*) The difficulty we have with these gentlemen is that they have got it into their heads that they would like to get their effluent into the sewers, because Sir Henry Roscoe did advise at the outset, where sewers existed, that they ought to have the right to go into the sewers.

28688. Who would be the chief man who would represent fellmongers if the Commission wanted to call a fellmonger ?—Mr. Clegg.

28689. You think he would come and say he knew full well it was quite practicable; that it would not be too costly ?—(*Mr. Stowell.*) Mr. Clegg is not a fellmonger pure and simple; he has other processes. Messrs. Whitehead are the largest fellmongers, pure and simple. At Mr. Clegg's works the process of manufacture is carried out from the fleece to the flannel.

28690. You have not many tanners in your watershed ?—(*Mr. Scudder.*) We have a lot of tanners, but the trade effluent goes into the sewers.

28691. These two efficient have tanks and filters ?—Tanks and filters. (*Mr. Stowell.*) The tanners' works on our list only require very small tanks.

28692. We have been told it is very difficult to produce a non-putrescible filter in a tannery ?—(*Mr. Scudder.*) No, if you have sufficient area—a great many, not on our list have land treatment, and it is all soaked up in the land; land treatment is most efficient.

28693. May I ask whether there is any difficulty caused by the lime refuse making the river water harder ?—(*Mr. Scudder.*) Yes; litigation is always going on in regard to that; there is always half-a-dozen cases going on in regard to that, but it does not affect us from our point of view.

28694. (*Secretary.*) You do not take action in that case ?—No, sir.

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28695. Why not ?—It is not necessary to do so, and any plaintiff has the remedy in his own hands.

28696. The question is whether it should be interfered with. After all the water can hardly be called harmless if it is exceedingly hard. It depends upon what you call harmless; it may not be harmful to health, but it is not harmless to boilers; there is no qualification in the Act ?—The man who suffers has a very good case to go to court with, and he can get his damages and get them assessed. We do not want to interfere with him there; we do not in our watershed interfere with that. I know one case outside our watershed where there is litigation going on at the present moment.

28697. You think it is best left to private litigation ?—Yes, sir.

28698. Every form of pollution might be left to private litigation, but I do not think that would come under it; it is a public nuisance ?—I am not so sure I would not allow that even. As a rule it generally gets settled satisfactorily; I do not know any case which has not been settled satisfactorily by litigation.

28699. (*Chairman.*) Well, gentlemen, we are very much obliged to you for coming before us, and giving us this very interesting evidence.

NINETY-FIRST DAY.

Friday, 11th June, 1909.

PRESENT:

Sir William Ramsay, K.C.B., F.R.S. (*in the Chair*).

Colonel T. W. Harding, J.P., D.L.
Sir William H. Power, K.C.B., F.R.S.
Mr. T. J. Stafford, C.B., F.R.C.S.I.
Mr. R. A. Tatton, M.Inst.C.E.

Mr. F. J. Willis (*Secretary*).

ALSO PRESENT:

Dr. A. C. Houston.
Dr. George McGowan.
Mr. G. B. Kershaw.
Mr. C. C. Frye.

Mr. James N. Tod, Managing Director of Messrs. Kelsall & Kemp, Ltd., and Mr. Francis D. Toyne, M.A. Cantab., F.C.S., called in; and Examined.

Mr. James N. Tod, and Mr. Francis D. Toyne, M.A.

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28700. (*Chairman.*) Perhaps I may ask some questions formally. You, Mr. Tod, are connected with Messrs. Kelsall & Kemp, Ltd. ?—(*Mr. Tod.*) I am a managing director.

28701. You, Mr. Toyne, are the chemist of the firm ?—(*Mr. Toyne.*) I am the chemist.

28702. I notice you state that your works are situated at Norden, Lancashire, and that you employ about 130 workpeople in finishing and dyeing about 18 tons of fine woollen cloth and flannel weekly. You use about 12 cwts. of soap weekly for cleansing the cloth, but you do not wash woollens. Does this process continue during the whole year ?—(*Mr. Tod.*) Yes.

28703. Then your works run on an average fifty hours per week, and you turn out 35,000 gallons of effluent an hour, 60 per cent. of which is soapy liquor, and the remaining 40 per cent. dyehouse effluent; these are treated separately. The object of treating them separately, I suppose, is that your dyehouse effluent will not be improved by treatment along with soap ?—No; they have to be treated separately; soap needs different treatment.

28704. I know it does, but would it not serve to remove your colour liquors; would not they be absorbed by the insoluble soaps ?—A large quantity of dyehouse effluent is treated, and it is a simple and much more easy method than the method of treatment of the soapy effluent, and gives a good result. It would mean a considerable extra expense without getting a better effluent, we consider, if it were treated in the same way that the soapy effluent is.

28705. It only occurred to me that the precipitation of soap would serve to take the colour out of your dyehouse effluent. Is the difficulty the dealing with a very much larger volume ?—They are approximately equal volumes, 60 and 40 per cent. There is a considerable expense in plant, an outlay running to several thousands of pounds treating it specially, whereas the outlay for treating it in the ordinary way, for dyehouse liquors will treat themselves, is not very great.

28706. I quite see that, but my point is this: Supposing you were to add to the soapy liquor this 40 per cent. of the dyehouse liquor, and treat them together would that entail any larger expense than treating the soapy liquors separately ?—(*Mr. Toyne.*) Yes, very much larger, because the amount of magma from the dyehouse liquor contains no grease at all, and therefore we should have to enlarge the plant very considerably and put down fresh presses to treat the magma from the dyehouse.

28797. You find that the various materials from the dyehouse precipitate each other very largely ?—They do.

28708. Are some of them acid and some alkaline ?—Yes. The general effluent is practically neutral or slightly alkaline; never acid.

28709. What is the colour of your effluent ? I am quite aware in special cases you have brilliant colours, but is your effluent from the dyehouse liquor usually yellowish ?—No; it is usually colourless, except under certain conditions; certain dye stuffs are very difficult to precipitate.

28710. I know; greens, for example ?—Well, more especially blacks, and there is a blue dye we use which is very difficult to precipitate; 30 per cent. of the samples usually contain traces of colouring matter in solution.

28711. That, of course, does no harm ?—Well, if we were using that water again it would do very considerable harm.

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28712. Is it so dark as to stain your white goods ?—It would stain white goods.

28713. Then, I see, to precipitate your soapy liquors you add lime and ferrous sulphate, and a man attends to the precipitation and regulates the proportions of the precipitants. Then you pass your liquors through settling tanks so as to settle out the insoluble soaps, and then through two ash filters into the river. Your water is very fairly pure, I suppose, after the soap is removed, except that it is hard ?—(*Mr. Tod.*) Except for hardness.

28714. I notice you state towards the end of your paper that this water could not conveniently be used again by yourselves owing to its hardness. That comes to saying, supposing there was another work of the same nature further down, the proprietors of that work could not use it ?—That is so.

28715. Would it be worth your while softening the water so as to bring it down to 7 or 8 degrees of hardness ?—The effluent from the soapy liquor is occasionally very hard, and Mr. Toyne has tested up to 37·8 degrees of total hardness.

28716. The effluent from the soapy liquor alone ?—(*Mr. Toyne.*) From the soapy liquor alone.

28717. That is chiefly calcium sulphate, I suppose, permanent hardness ?—Yes, almost entirely permanent.

28718. Softening then would require to be done by the addition of carbonate of soda and lime ?—Yes.

28719. Would that be an expensive process ? Would it pay you to do it ?—No, I do not think it would. (*Mr. Tod.*) Not when we have plenty of pure water.

28720. I am thinking of the people lower down the stream. Supposing they had works lower down the stream they might object to you giving them such hard water ?—In that case I think we should use Corporation water.

28721. And not be obliged to return the water to the stream ?—Yes.

28722. I notice you say that there is an apparent gain of £135 in cracking the soap, but a net loss of about £400 owing to the interest on capital, depreciation, rent, steam used and supervision not being taken into account in your statement ?—That is so.

28723. Do you generally use iron in excess in precipitating soap ?—(*Mr. Toyne.*) No.

28724. It would be merely accidental if you happened to have excess of iron in the water ?—Yes. Of course, it is exceedingly difficult to regulate.

28725. Then I should like to ask you one or two general questions. Do you receive the water in a fairly pure state from the stream ?—Five to seven degrees Clarke hardness and about 8 grains per gallon of solids in solution.

28726. That is a very fairly pure water ?—Yes.

28727. Is it colourless ?—It is colourless, quite.

28728. No sediment ?—No sediment.

28729. Are there works above you on the river ?—(*Mr. Tod.*) Yes, but we receive water from the reservoirs ; it is compensation water. The bulk of the water comes from the Heywood and Middleton Reservoirs, and they are obliged to send down compensation water which is shared between two or three works on the stream. But we do not pump the water from the stream, we pump through a special supply.

28730. There are no works below you ?—Yes, there are works below us.

28731. And do they not require pure water ?—I am not sure, but some of the works below us share the water that we use and others are not finishing works. Of course, for ordinary manufactures, for boilers and so on, and turbines they use the ordinary stream water.

28732. And do they not object ? You have never had any difficulties, have you ?—We have certainly had one difficulty with one firm below us. We had a case that was carried to the House of Lords, and which was decided in our favour.

28733. Without giving the figures, was it an expensive trial ?—It was a very expensive trial, even though we succeeded in getting our costs in the end.

28734. Then do you think such a question as that would be better settled by what the Commission has been recommending for some time past, namely, a Central Board which would decide on the facts of the case ? I presume a large portion of your expense was in getting the facts of the case represented by the counsel ?—Yes.

28735. Would it be an advantage to have a central board which would send up expert persons to investigate the case and determine the facts on which the legal decision, if there is to be a trial, would be based ?—I should not like to say offhand. I never heard it suggested before.

28736. Do you think that this litigation of yours has stopped litigation in future, or does it not influence it ?—Of course, we consider the litigation was unfair from the beginning. We offered without demur to pay for any damage shewn. As they could show none, we thought we had the rights of the case ; we fought it out ; we thought we were the aggrieved parties all through, in which case we wanted to fight as long as we could in order to prove that we were right.

28737. But has this decision prevented other people from litigating ?—I really could not say.

28738. You do not know ?—No.

28739. Have there been other cases besides your own ?—Not that I know of.

28740. Is it long since this litigation took place ?—I think it began about fifteen or sixteen years ago.

28741. (*Mr. Tatton.*) Would your dye waste effluent be as bad, do you suppose, as from an ordinary woollen dyehouse effluent. What I mean is, does not the wool absorb much more of the dye than cotton would ?—Yes, certainly. Occasionally we dye cotton, and it is when we are dyeing cotton that we have the trouble by precipitation, but in all alizarine colours, of course, the bath is totally exhausted in practically every case, and the liquor from the dyebath itself is colourless.

28742. And if you mixed your dye-waste with the waste from the piece washing you would be mixing a very large volume of very weak stuff and a comparatively small volume of very bad stuff ?—Yes.

28743. And that is one reason why you keep them separate ?—Exactly.

28744. And treat them separately ?—Yes.

28745. Do you require really pure water for your final washing ?—It is very necessary for us.

28746. You have a separate supply. You do not take it from the stream ?—No, it is sent down to a reservoir which is above us, and we pump from this. It runs through a tail loose ; it is not used for any manufacturing purposes, and we pump from that ; and, though the water is so pure, we have to filter it over again for traces of organic matter.

28747. You have no effluent discharging into your water supply have you at all ?—No ; it is all carried below us. There are arrangements with one or two mills above us. It has been privately arranged that their effluents should be piped down below our intake.

28748. Then do you think, generally speaking, would it be possible for all woollen works on a stream to use water into which effluents from other woollen works had been discharged above you ?—It would be, practically speaking, impossible. If, for instance, a bleach works were above the chlorine from the bleaching liquor—there is bound to be some chlorine in the effluent—would be very injurious.

28749. But you think it would be a heavy cost, would it, to bring your effluent to such a condition that it would be possible to use it ?—I do not think we could do that. We would use Corporation water if we were driven to that.

28750. You say that you use ferric iron as your precipitant. You tried other precipitants ; have you tried alumina ferric at all ?—Alumina ferric was tried. I think before Mr. Toyne's time we tried alumina ferric—I do not know with what success, and then after a time we used perchloride of iron, and that was expensive ; and since Mr. Toyne came he has used copperas partially oxidised with commercial nitric acid. We have done that simply on account of the expense. We find it equally efficient.

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28751. Then do you think on the whole it would be fair to ask manufacturers to do as much as you have done. You would naturally ?—I think in many cases it would be rather hard; it takes a good deal of capital to do it. I do not know the figures exactly, it is a good long time ago, but on different plant we must have spent, I should think, very nearly five figures; on plant connected with the water treatment.

28752. You think you have a more perfect plant than most other woollen manufacturers ?—I think in times past we have tried to be as good as possible, not from a commercial point of view, but from sentiment.

28753. You do not do wool scouring do you at all ?—Not at all.

28754. That is done at Rochdale ?—Yes.

28755. (*Colonel Harding.*) Mr. Tod, you said just now that your expenditure might possibly reach five figures, but I understand that the cost of your plant had been £1,600; not £1,600 a year, was it not ?—The cost of it to us was £1,060 during 1908, and our income from it was about £1,200.

28756. Then what would be the capital cost of the works ?—I should think, I cannot say offhand, they are rather extensive, that the clean water reservoir and everything taken altogether would cost at least £10,000.

28757. And the annual cost, including the charges for interest and sinking fund on the outlay would be represented by about £1,600 ?—I hardly think £1,600. We mentioned the expense for the year was about £1,000 to £1,060.

28758. From the notes I took at the time of my visit I find the statement here that the total cost per annum was £1,600, the returns about £1,200, so the net cost would be about £400 ?—That is the total cost; that includes depreciation and running expenses, and a good part of these running expenses are due to such things as stills and so on for making soap, which bring in the revenue, of course.

28759. Then the net cost to your firm is £400 a year ?—At present.

28760. For carrying out works which satisfy the Rivers Board ?—Yes.

28761. Would you tell us whether these works were carried out under any pressure by the Board ?—I do not think so as far as I know it; I should not like to say. I have only been connected with the firm for twelve years. I do not know whether Mr. Tatton would possibly know whether the works were carried out under pressure from the Rivers people or not.

28762. (*Mr. Tatton.*) No; I think not. On the whole they did improve the works very much, but I think the managers recognised the thing had to be done. It was not necessary for the Board to bring any direct pressure ?—No.

28763. (*Colonel Harding.*) And we are to take it that your firm do this willingly ?—Voluntarily, without any pressure.

28764. And without deriving much benefit from the improvement of their effluent ?—Yes, certainly; it was done largely with the idea of turning out as good an effluent as we possibly could.

28765. (*Chairman.*) I suppose, to begin with, there was some profit that might be gained on the whole by the saving on soap ?—It was not certainly done commercially; our managing director at the time was very particular about these things, and he was very anxious to turn out the very best effluents he could apart from the expense.

28766. (*Mr. Tatton.*) I think I may say this, that from the beginning the purification works at these particular works were about the best we had in the watershed, or one of the best, and, therefore, we should not have brought any pressure to bear upon them naturally.

28767. (*Colonel Harding.*) And in carrying out this work you have been able to obtain some return so that the cost to your firm has not been very serious ?—We considered that if we carried out works simply to satisfy the Rivers Board, and no more, the yearly loss would be as heavy as the net loss would be, and is, with expensive plant and the best effluent obtainable.

28768. But, as a fact, it has not been too serious a charge upon your firm ?—For a long time it was, before we had a fully qualified chemist. Before Mr. Toyne came we had very heavy losses in some years. We just had a man on the spot who did what he could, but in the last three or four years we have made considerable improvements.

28769. That is rather an interesting point. We are to take it that you have found advantage in getting scientific advice upon these matters ?—I should say certainly. You have been pointing out in many ways that you have been able to improve on the effluent have you not ? (*Mr. Toyne.*) Yes.

28770. Although the effluent is of no utility to yourselves—for you do not use your effluent again—you think carrying out these works must be of considerable value to the people below you on the stream ?—I may say, compared with other effluents, that our effluent improves the stream.

28771. Your effluent is, I believe, very hard ?—Not very hard.

28772. It is much harder than the water that you use ?—We reckon about 9 or 10 degrees harder than the water we use.

28773. You have no information have you, as to how soon that hardness is lost in the stream by admixture with the natural waters ?—No; we have not made any tests in that direction.

28774. How near to you, on the stream below you, are there any works ?—Immediately below.

28775. Have they any difficulty in using the water consisting of the natural stream plus your effluent ?—I do not know that they have any difficulty; but the mills above us and our mill turn effluents out together, and so any difficulty that they might have had might very possibly be due not to our effluent, but to other people's; but I do not know that they have had any difficulty; they merely use it for a turbine, and I do not know whether they use it for steam raising, but they use pure water for finishing.

28776. But would you not consider that the purification of trade effluents is of very great value indeed to the manufacturer on a stream ?—Very much so. At our Rochdale works we are now using the river water for our boilers, not for finishing, and that is considerably harder than our own effluent at Norden. We only wish we could get water that is as free from dirt, and is as soft as the effluent we are turning out at Norden.

28777. So that in carrying out purification works manufacturers are not merely improving the amenities of the river or stream, but are doing work which is of great value to manufacturers using the stream ?—It is of great value to any one using the stream certainly. Although they may not be able to use the water for all purposes it helps them very much in their boilers for steam raising, and prevents the accumulation of scale and dirt in the boiler.

28778. And you are of opinion that the policy of the Rivers Boards in endeavouring to get manufacturers to purify their effluent is valuable work ?—It is certainly as long as they are reasonable. We think they ought to do all they can.

28779. And have you formed the opinion that it is possible in every case to considerably improve the effluent, if not to bring it up to your own standard ?—We have no experience apart from our own works.

28780. (*Chairman.*) Does the amount of water you return to the stream bear a large proportion to the volume of the stream ?—Yes, a considerable proportion. I believe the amount of compensation water is $1\frac{1}{4}$ million gallons daily, and there is some little extra water, probably not very much in the dry season, and we are using 300,000—probably one-quarter to one-fifth of the total quantity.

28781. (*Mr. Tatton.*) Mr. Tod, with regard to the question of fixed standards, would you rather have a fixed standard on the stream, or would you rather work under the present Act which requires you to carry out "the best practicable and available means." Have you considered that point at all ?—We have considered it. Of course, in certain cases a fixed standard might hit a

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particular manufacturer rather hard. On the other hand, you know you have something to work for; you know you are right, whereas at present no one is safe. You never know. If everyone was squeezed up to our level possibly then we might be seized on and told: "Now, you must turn out something better than this.'

28782. You mean if some improvement was brought out you would all have to carry it out ?—Yes.

28783. Then would you have one standard; could you work with one standard for the whole of the trade or would you have different standards for different rivers ?

28784. (*Chairman.*) Might I ask a question first. Would you have a standard applying to the effluent or to the stream, plus the effluent ?—We are only concerned with our own effluent.

28785. It is obvious that if the volume of the effluent bears a very small proportion to the volume of the stream it would be permissible to have a lower standard than if you are turning out an effluent which bears a large proportion to the stream ?—Certainly, if one is using the ordinary stream. In our case we do not use the stream, so it does not affect us.

28786. You are mixing your effluent with the stream; the question is should the standard apply to the mixture of this effluent plus stream, or to the effluent alone. Have you any views on the point ?—In our case it is never used. If anybody turns out a bad effluent below the point at which we are taking the water, but above the point at which we are turning it out, that stream will be very much worse than our effluent. In that case stream plus our effluent would be unjust.

28787. (*Mr. Tatton.*) Therefore you would have to have the standard on the effluent ?—Either on the effluent or on the effluent plus our water supply.

28788. But you think it would deal hardly if you had one standard over the whole of the trade, we will say ?—It seems to us the easiest way out of the difficulty.

28789. You would have to have only one standard ?—One standard.

28790. Could you not have a varying standard at all ? If you have a standard at all it must be one fixed standard ? Yes.

28791. Then you will have difficulties where works are so closed in that they cannot carry out such efficient works as you have put down ?—We hope if the standard were fixed we would be above the standard and it would not cause us any trouble, but in particular circumstances we might have a very hard or bad effluent, and then a fixed standard might hit us, while letting other people off. I understand a fixed standard for one particular trade; you would not have the same fixed standard for dye works and wool scouring, for instance.

28792. No; one standard for one particular trade ?—One trade.

28793. (*Chairman.*) The point is that the effluent should not prove a nuisance. That means, I presume, after it has entered the stream ?—Yes.

28794. Therefore the standard theoretically should be fixed on the stream plus effluent, but whether it might be more practicable and advisable to fix it on the effluent alone, irrespective of the volume of the stream into which that effluent flows, is a matter on which we should like your opinion ?—In our particular case, other people are turning out effluents into the river below the point at which we draw, and above the point at which we turn it out. If you take the stream where we turn our effluent out you might get a very bad result, but that might be due to other people and not to ourselves.

28795. (*Mr. Tatton.*) All you can be answerable for is what you turn out yourselves ?—Yes.

28796. (*Chairman.*) Thank you; we are very much obliged to you.

NINETY-SECOND DAY.

Tuesday, 15th June, 1909.

PRESENT.

The Right Hon. The Earl of IDDESLEIGH (*in the Chair*).
Colonel T. W. HARDING, J.P., D.L.
Sir WILLIAM RAMSAY, K.C.B., F.R.S.
Sir WILLIAM H. POWER, K.C.B., F.R.S.
Mr. T. J. STAFFORD, C.B., F.R.C.S.I.
Mr. R. A. TATTON, M.Inst.C.E.
Mr. F. J. WILLIS (*Secretary*).

ALSO PRESENT.

Dr. GEORGE McGOWAN.
Mr. C. C. FRYE.
Mr. G. B. KERSHAW.

Mr. A. J. KING, M.P., B.Sc. (London and Manchester), F.C.S., Director of the Bleachers' Association, Bollington, near Macclesfield, called in; and Examined.

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28797. (*Chairman.*) We are very much obliged to you, Mr. King, for coming very kindly to give your evidence, and also for this statement. Will you allow this statement to be printed and appear in the evidence ?—Oh yes. I have no objection, if you think it is of any value.

28798. I think that would be a convenient way, because then we can get your views put as a whole ?—It was meant as a basis upon which you could ask me questions.

28799. If we may put it like that, and, of course, a proof will be sent you for correction ?—Yes.

I am a Director of the Bleachers' Association, Limited.

I am also Managing Director of the following branches of the above Association.

(1) *A. J. King & Co., Ltd.* Works: Ingersley Vale, Bollington, near Macclesfield.

The works are on the River Dean, in the Parish of Rainow, just outside area of Bollington Urban District Council, and just above Bollington on the river.

In dry weather the flow of the river is very small, and practically all the water is used in the works for one purpose or another before passing on.

In the Bollington area are various mill dams which impound the water and act as settling tanks, and thus tend to increase any nuisance which may arise from bad effluents.

Other works on the same stream and in the Bollington area which contribute to pollution of the river are:—

(1) A brewery.
(2) Paper-staining works.

There is also a calico print works on another branch of the Dean, which joins the Rainow branch in the centre of Bollington.

(2) *Messrs. Melland & Coward*, bleachworks, Heaton Mersey, near Manchester.

These works are on the Mersey, below Stockport.

There is a much larger volume of water here, but it is at times badly polluted before reaching Heaton Mersey.

For bleaching purposes water is taken partly from the river, and partly from a deep bore-hole in the new red sandstone.

(3) *Messrs. Horridge & Co.*, Raikes Bleach Works, Bolton.

Situated on the River Croal. This river is very badly polluted, and quite unfit for bleaching purposes.

Independent water supply from springs, stored in reservoirs.

(*N.B.*—Any evidence I may give or any opinions I express must be taken as my own personal evidence and opinion, and not in any way as committing the firms which I represent.—A. J. K.)

It will be observed that the conditions with regard to the three works named above are widely different in many respects.

For instance, in the case of the works at Heaton Mersey and at Bolton, owing to the volume and condition of the water in the river, however bad the effluent turned in, it would not be apparent to the eye a few yards below the works.

In the case of the Bollington works, which are the first works on a small *trout* stream, any solid or coloured effluent makes its presence known for a long distance down the stream.

As a matter of actual practice, and from a trader's point of view only, this state of things does act rather hardly on a works situated as the one at Bollington, owing to the fact that pressure is most constantly brought to bear upon the Rivers Committee by private individuals and by the Local authority than is the case either at Heaton Mersey or at Bolton, to maintain a high standard of purification.

Moreover, the Bollington works have paid a high rent for the privilege of first use of the water, dating from a time before the Joint Rivers Committee had any existence.

At the same time, it would obviously be absurd to enforce on a works like the Raikes at Bolton—an effluent purified out of all proposition to the condition of the river into which it flows.

In dealing with a river like the Croal at Bolton you must either begin at the top and work down or you must insist upon all works simultaneously improving their effluents.

I think it would be fair to set up a common standard for all bleach works, but liberty should be given to the authority to exercise discretion as to how far and within what period of time it should be enforced in the case of an important stream on which there are many works.

I do not think anyone can expect to make a river like the Croal suitable for manufacturing purposes in its lower reaches, but from a sanitary point of view a great improvement is needed. In hot weather the river is most offensive and must be injurious to the health of those who have to work and live on its banks.

Before leaving the point of uniformity of standard I may point out that difficulty will arise not so much from the point of view I have already discussed as from other circumstances.

The main difficulty is dealing with bleachers' effluent arises :—

(1) From its relatively large volume ;

(2) From the nature of the pollution ;

which is largely the result of boiling grey cloth (strongly impregnated with size and other organic matter added in the process of weaving) with alkalies—sometimes lime—often caustic soda or carbonate of soda.

The soda and soda salts cannot, of course, be precipitated, and they are too dilute for it to be practicable to remove them by evaporation. Settling tanks and some kind of filtration appear to be the best methods of getting rid of other impurities.

In some cases it will be found that there is not space available within the precincts of the bleach works for this to be effectively carried out.

In any case the disposal of the sludge from the settling tanks is often also a practical difficulty, and a very costly process.

It has been suggested that the burden of the removal of the sludge should be thrown upon the Local Health Authority, but in this case the further question would arise as to the standard of dryness which would be insisted upon before it was removed. The sludge is often very wet, and to dry it to a certain standard might be as costly to the manufacturer as its total removal by present methods.

With regard to methods, I can only speak of those I know. Settling tanks are, I think, a necessary preliminary to any process, and I do not think any advantage is gained by the addition of chemicals to aid precipitation.

With large enough tanks I should say that most of the suspended solids can be removed, and a good deal of the solid matter originally in solution.

At Bollington we have in addition to the settling tanks cinder beds with Mather and Platt's rotating arms.

I am not sure that this further process is any improvement.

The cinder beds are not so much filter beds. They are rather the means of setting up a further fermentation in the course of which there is a great development of bacterial and other animal life—notably a small red worm—they also breed innumerable small flies. They give off in the summer a most unpleasant odour, and give rise to frequent complaints from people living or working near the river below the works.

They may improve the effluent from the point of view of the Manchester Ship Canal, but they certainly do not improve it from the point of view of those who live near.

I believe if the effluent from these beds could be finally submitted to land filtration or even to a further settlement in tanks an improvement would be effected.

We have, however, no accommodation for either processes. I may say that the effluent before it reaches the tanks is quite free from solids in suspension. After leaving the cinder beds it contains a considerable quantity of flocculent precipitate. This precipitate appears to contain most of the offensive matter.

It may interest the Commission to know that some years ago we turned our effluent into some old coal workings. The result being after a few weeks it made its appearance a little lower down the stream in the form of a strong solution of sulphuretted hydrogen, and the experiment had to be abandoned.

28800. So far as I am concerned there are only just two questions that I wanted to ask you. In your statement you say: "Liberty should be given to the authority." Did you mean by that the Central Authority that we are so anxious to get established ?—I was not thinking of that at the time. I had the local authority in my mind.

28801. The local authority ?—Yes.

28802. Which local authority ?—In my own case the Mersey and Irwell Joint Committee.

28803. The Rivers Board ?—Yes.

28804. And then you say that you do not think any advantage is gained by the addition of chemicals to aid precipitation. Well, do you speak there from experience ?—Yes ; we have tried it.

28805. You have tried chemicals ?—Yes.

28806. Have you tried many different sorts ?—I think we have tried ferrous sulphate and lime, the usual precipitants. I do not think that we gained very much by them.

28807. (*Sir William Power.*) Did the addition of precipitate greatly increase the sludge you had to deal with ?—I do not think it did.

28808. (*Mr. Tatton.*) You have three works in charge, Mr. King—Heaton Mersey, Bollington, and at the Raikes ?—Yes.

28809. At Heaton Mersey you speak of having difficulty with the water being so highly polluted in the river before it comes down to you. Are there any special works, do you think ?—It is an iron pollution that gets in ; we believe it comes from some zinc plating works, galvanised iron works higher up the river. On certain days we cannot use that water for bleaching purposes on that account.

28810. You cannot settle that out ?—No.

28811. It really spoils the water for bleaching entirely, does it ?—Yes ; it stains the white cloth.

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28812. Are any means being adopted now ?—I think it is better.

28813. Better than it used to be ?—Yes ; I have not heard anything of it the last six months.

28814. It is chiefly during the dry weather, in summer ?—Yes ; on special days it comes down for a few hours generally.

28815. Then is that the chief thing that you have to guard against in bleaching—the iron ?—That is the only thing that does serious damage.

28816. It does more harm than anything else ?—As matter of fact, you can bleach now with almost any water, if you have clean water to wash up with afterwards.

28817. Well, then you go on to speak of another works you have charge of. Is that of Messrs. Horridge & Co.'s works at the Raikes ?—Yes.

28818. At those works also you speak of the condition of the river as being very bad ?—It is just generally bad. I may say there is no special pollution there.

28819. Is not that pollution by bleach works chiefly as matter of fact ?—I daresay they contribute. It smells of sewage almost. I suppose there is not much sewage in it now.

28820. It is black mud ?—It is a very black, filthy smelling fluid that comes down the river in dry weather.

28821. But there are several bleach works on that river above you ?—Yes, there is one just above us, and I daresay many more higher up.

28822. Do they purify their waste as efficiently as you do, do you think, at these works ?—I do not think any of us are very efficient on that river.

28823. They do not, any of them, purify efficiently ?—As far as I know they use settling tanks not very efficient ones ; certainly the works immediately above us do not seem to do anything at all.

28824. But if we could find out a satisfactory way of treating bleachers' waste it would make a very great difference in the river ?—Oh yes, very great.

28825. You would be able to use it for your works ?—I should think so—for the earlier treatment any way, for the first washes.

28826. And you suggest that in a river like the Croal at Bolton you must begin at the top and work down, or you must insist on all works simultaneously improving their effluents ?—I think you would have great resistance from any works if you asked them to produce an effluent which is purer than the river it is going into.

28827. If you put them all on the same standard, so to speak, that would get over that difficulty ?—I should think so.

28828. And do you think that a standard would be fair—I mean to say, a fixed standard as regards bleach works effluent ? Have you considered that at all ?—May I suggest now what I was rather suggesting to you before the meeting. In the old days, at any rate, it was rather a hardship for individual works simply to be told by the Rivers Authority : " We have analysed your effluent ; it is not good enough, there is too much suspended matter or too much organic matter in solution." But they gave us no advice as to how to deal with it, and each individual works had to struggle with the problem itself. It seems to me that either the Authority itself should be in the position to give some advice or they might call together a meeting of all the members of a particular trade and ask them to consult with them either directly or through an engineer and a chemist of their own, and see whether some general scheme could not be worked out in connection with the trade to arrive at some practical process for dealing with this effluent. Suppose each works is struggling with its different problems, it is a great deal of effort wasted. Some works keep chemists and some do not, but in any case no one knows what the others are doing, and that was especially so before the formation of the Bleachers' Association at the present time. About fifty of those branches are now under one control. I think it might be comparatively easy to get them to appoint some expert to work with the Commissioners, and see whether in conjunction they could not work out some scheme which might be adopted as the standard of all works of the same kind.

28829. You would suggest a chemist from your Association being appointed to work with us ?—I should suggest, first of all, that the Rivers Board should call a meeting of all the members of the particular trade, and confer with them as to what means should be taken, either by appointing a chemist to confer with you, or——

28830. Then would you select some works to experiment on, we will say, to put down an efficient plant ?—Well, I should leave that to be discussed by the meeting. My great point is that the Rivers Authority should come into direct contact with the trade as a whole.

28831. Quite so ?—Rather than dealing with each individual works.

28832. Then you think that, generally speaking, you would be able to get all the bleachers up to a certain standard ? Of course, there are some bleachers in the middle of Bolton, are there not ?—Oh, yes.

28833. Where they might have some considerable difficulty in putting down plant ?—There would be difficulty in regard to finding area for their treatment, but those cases would have to be considered on their merits. It would be a great thing if you could first of all establish what was the best process, provided you had room and space, and then you would have to modify that process according to local circumstances. At present, we are all more or less in the dark.

28834. Yes, but you would have some definite standard, some definite chemical standard, we will say, of suspended matter, and so on ?—Yes, I think that is so.

28835. You would rather have that than the present arrangement of the best practicable and available means ?—Well, it would have to come to that in the end, but it would be well to have a basis ; some idea on which to work.

28836. You would have some sort of elastic standard you mean ?—I think so. If the works were so situated that they could not carry out the process you would have to make some sort of an allowance, unless you were prepared to close the works. At the present time, there is no common method. The Rivers Committee will not tell us what method to use, the Mersey and Irwell Committee, I mean.

28837. No ?—If they do it is done unofficially through their inspectors, but their position is : " If our effluent is impure, you have got too much pollution in it ; you must get rid of it," and there it ends with them. It seems to me that is a wasteful method. The Committee should either themselves or, in consultation with the trade, try and find out what is the best method, and be prepared to advise that.

28838. I suppose what they do is to tell you where good results have been obtained ?—Yes ; they say you can go and look and so and so.

28839. But you think that still there is difficulty in knowing what to do ?—I should say so, yes. I think all these things work better if the authority is in touch with the people affected as an organised whole. If you could meet them in formal consultation.

28840. (*Colonel Harding.*) In the works at Bollington, Mr. King, we had the advantage when we visited them of seeing an interesting installation in which you had the liquors, including the Keir liquors, dealt with through a tank, and finally over filters ?—Yes.

28841. The suggestion was made when we were there that the effluent from those filters was unsatisfactory because of the too great volume passing over them ?—Yes.

28842. And the suggestion was made that much interesting information would be obtained if you could reduce the volume passing through the filters very considerably, say, to one-fourth ?—Yes.

28843. Has anything been done in that direction since, do you know ?—I do not think so, but it was mentioned to me.

28844. As you have the installation it would be very interesting to get that information ?—Yes.

28845. Because, so far as we could judge, the passage of that tank liquor over the filters produce practically no result ?—It does produce a result, but I quite agree it is much too rapid.

28846. If you were able to reduce the flow very considerably, experimentally, say, to one-fourth, it would probably lead to valuable information being obtained as to the treatment of these liquors ?—Yes, it is rather difficult because the mechanical movement of the arms depends upon having a certain amount of liquor flowing through it. If you reduce that to one-fourth, I do not think those arms, under the present arrangement, would go round, therefore you would not get it distributed.

28847. Although that distributor would not allow you to diminish the volume so much as you suggest, probably another distributor would enable you to do so ?—Yes.

28848. If you set it on one filter it might give valuable information to you and to the Committee ?—Yes.

28849. I suggest to you that that is a direction in which they might help us very much ?—I think it is ; I will bear it in mind. That rather bears out what I was saying just now, that if the trade were consulted as a whole, and had an adviser as a whole, they could undertake such an experiment as that in one particular branch, and the whole trade would have the benefit of it.

28850. The suggestion you have made to us seems to be a very valuable one. Have you at present any Bleachers' Association at all ?—Yes, we have.

28851. Then we will approach that body at once ?—Yes, and they have both an Engineer and a Chemist.

28852. And does that embrace practically the whole of the bleachers ?—No, they embrace about fifty branches ; I daresay there are twenty or twenty-five outside, but to some extent they are in touch with those.

28853. They might be considered as representative of the bulk of the trade ?—Yes.

28854. And have you reason to think they would consider favourably a suggestion from us to carry out, under our direction, certain experiments at their expense ?—Well, I cannot speak for them. I have not consulted them on that evidence before I came up, but I should rather recommend that you approach the Bleachers' Association directly, and ask them to give evidence.

28855. Then we may take it from you, Mr. King, that if it were shown that there are practicable means to purify those effluents, to a certain point the bleachers would be ready to undertake the necessary works, assuming of course that they are practicable ?—I do not want to commit them, but they are doing a certain amount at present. I suppose they are doing as little as they can to escape the censure of the Joint Committee.

28856. The bleachers recognise that it is valuable to the trade generally that the rivers should not be allowed to go from bad to worse ?—Yes.

28857. They recognise that ?—I think you may take that.

28858. I think it is to the general advantage, and possibly to their own, that work of this kind should be carried out ?—Yes. I think you should communicate with the Bleachers' Association, and ask them whether they would care to give evidence. I really only represent one branch out of a large body. I should think they would prefer to give evidence themselves.

28859. (*Secretary.*) What is their address ?—4, Norfolk Street, Manchester. The Secretary is Mr. R. H. Eccles.

28860. (*Sir William Ramsay.*) I should like to put some special questions. In your statement you say that in the Bollington area there are various mill dams which impound the water and act as settling tanks. The next sentence does not appear to me to be clear : "And thus tend to increase any nuisance which may arise from bad effluents." Why ?—I mean it holds it up. If the effluent went straight into a running stream, and went right away down into the country, it would more or less get *aerated*, and would not be so perceptible.

28861. They are practically septic tanks, these settling beds ?—Yes, they are practically right in the heart of the population, right below those works. The water never gets away.

28862. Putrefaction goes on in them ?—Yes.

28863. (*Colonel Harding.*) Is there not something more ? Are not those dams flushed at times, and the solids held up and run off all at one time : Are they ever let off ?—We used to do it in the old days ; when a thunderstorm came on we opened the dam and put men in, and the sludge was sent down the river.

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28864. It is not done now ?—No, we are not allowed.

28865. How is this material removed ?—It is not removed.

28866. Well, it cannot accumulate indefinitely.—I have never seen it let off in the twenty-five years I have been there ; our own pool above we have emptied out. That simply gets filled up with the natural detritus of the land.

28867. (*Sir William Ramsay.*) Mr. Tatton tells me you are not allowed to sludge that out ?—No ; as I say, we used to do it, but we are not allowed to do it now.

28868. That is a very curious state of affairs.—We used to take advantage of a thunderstorm to open the paddles, put men in to shovel the whole thing into the streams, and it went down.

28869. Does the Rivers Board object ?—It is the Ship Canal that is at the bottom of it. That thing came into effect after the Ship Canal was built. They did not like dredging it out of the River, and since then we have not been able to carry out that very simple method of getting rid of it.

28870. (*Mr. Tatton.*) We had no Rivers Board before the Ship Canal came ?—No.

28871. (*Sir William Ramsay.*) You state that some settling in the dams, and you are not allowed to attempt to purify your liquors, either by the Ship Canal or by the Rivers Board ?

28872. (*Mr. Tatton.*) They must keep it out of the rivers altogether. That is what we want them to do.

28873. (*Sir William Ramsay.*) But I am taking it that a settling tank is at all events a certain step on the way to purification.—Yes.

28874. But if it is to be sludged out and not to be treated, it ceases to purify. It is very absurd of the Rivers Board in their own interest not to allow you to remove detritus from these tanks in some sort of fashion.—The theory is that a certain amount of sludge helps the putrefaction and decomposition.

28875. But you ought to be allowed to empty the tanks. No septic tank could exist if you are compelled to fill it up ?—They would allow you to let it dry, and put men in with wheelbarrows and clean it out.

28876. (*Mr. Tatton*). We will allow you to do that.

28877. (*Sir William Ramsay.*) Is there any objection to doing that ?—It is rather expensive.

28878. (*Mr. Tatton.*) They may run the water down if they like, and take this mud out and deposit on land ?—That is a very expensive process.

28879. What they do is to run them down the river.

28880. (*Sir William Ramsay.*) But the actual practice is that every tank is sludged out ; whether it be a septic tanks or a non-septic tank, it is sludged out at intervals. Can you not do that in the same way ?—These are mere dams. We have no control over them.

28881. They are not yours ?—No, other works.

28882. But if there were some joint action, would not the first thing be to treat these settling tanks, these dams ?—The District Council at Bollington have given instructions to some of those mill owners to have their dams cleaned out, but it has not been carried out. The difficulties are tremendous from the situation of some of these mills dams right in the heart of Bollington.

28883. (*Mr. Tatton.*) I do not know whether it is quite clear to you. These dams are put across the river in order to utilise the water for feed purposes, and the owner of the dam has nothing to do with the pollution which comes down from above. He simply has the right of storing up his water to use it for feed purposes ?—That is it.

28884. And the dirt that gets in is sewage matter and refuse from bleach works, which settles in this dam. The dam would be perfectly right if it were not for the pollution above ?—But still it is not quite right to say it is all refuse from works, because in our dam which is above the works on the first water on the stream, I think that fills up more rapidly than any other, simply with the natural detritus from the land.

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28885. But your dam does not stink?—Oh, a great deal of that goes down and fills up the other tanks. No doubt it is polluted, but the bulk of the sludge, I should say, is natural detritus.

28886. That is to say, the bulk of it?—Yes.

28887. You get it mixed with this other stuff which creates nuisance?—Yes.

28888. (*Sir William Ramsay.*) Are there any bleach works on the river, or are there various works of various kinds?—On this particular river I think I mentioned there is a brewery just below, and a paper staining works, and then there is a calico printing works, which joins the stream here.

28889. Would it not be possible to get those various firms to join in conference on the state of the river? You need a conference in order to find out how to purify bleach works effluents, but do you not also want to know how to keep this river clean? Do you merely mean you would quarrel with the brewery and the other works afterwards? You have taken steps to purify your river, but the brewery and the print works must now make it pure?—My opinion is it would be much better to deal with each trade separately. They are not only dealing with this little village of Bollington, they are dealing with the whole watershed of the Mersey and Irwell, and if they confer with each trade, the breweries, bleachers and calico printers, to try and arrive at the best practical scheme for each particular trade, then they can begin to apply it in various districts.

28890. And you think it would be within the powers of the Rivers Board to do that, or of this Commission; which?—I think the Rivers Board; now they summon individual traders. My idea is that it would be better in the first instance if they would summon the whole trade rather to a friendly conference.

28891. Do you not think that that rather points again to the necessity for a Central Authority, which would act with very much more effect, not merely in that part of England, but everywhere else where there happened to be bleach works?—Very much better.

28892. Then you approve of the notion that there should be a Central Authority?—Yes.

28893. (*Secretary.*) His Lordship suggests that I should read a letter which the Bleachers' Association wrote to us, Mr. King?—Yes.

28894. The Commission asked them if they would give evidence?—What is the date.

28895. Their letter is dated June 1st of this year. They said:—

"We regret that we are comparatively ignorant of the aim and object of the Commission, and are therefore hardly able to judge whether any evidence that we could offer would be of service to the members thereof. At the same time we should greatly regret if by stopping away we were considered to show any discourtesy, and if the Commission expressed any wish to question the General Managers of this Association on any of the points embraced, they would be pleased to arrange for one of their number to attend.

"So far as the Manchester district is concerned, we have reason to believe that few fresh points have arisen for some little time past. Most of the bleach works are furnishing a standard with their effluent which meets the requirements of the local authorities, and those works which have hitherto failed to reach that standard are being pressed in a quiet way to so modify their arrangements as to give no cause for further complaint.

"Whether the large sums of money expended by the different employers has really had the desired effect, or has made the rivers and streams of this district any better than they previously were, is a very debatable point, but presumably there is little chance of this branch of the subject being re-opened, and so the present would not appear the proper time to discuss this aspect of the question."

It is signed by Mr. Arthur K. Davies?—He is Chairman of the Managing Directors.

28896. The letter which the Commission sent to the Bleachers' Association was a long letter, somewhat on the lines of the letter sent to you, setting out the sort of points that the Commission wished to hear manufacturers upon, and that is their reply. Of course, the Commission could approach them again now?—I think if you could let me have a copy of what has taken place to-day, I could send that on to them, and ask them if they would care to come and supplement it.

28897. (*Chairman.*) You would let us send on a copy of your evidence to them?

28898. (*Secretary.*) Mr. King said he himself would do it.

28899. (*Chairman.*) Oh, you would do it?—I could do it myself, or it could go from here. I should be very glad to bring it before them, if you would let me have a copy of what has taken place to-day.

88900. (*Secretary.*) We will send you two or three copies of your own evidence; half-a-dozen.—Thank you.

28901. (*Chairman.*) Then if you would not mind correcting the points in your evidence, and send it to Mr. Willis, he could send it on to the Association.—Yes.

28902. It would be better that you should correct it first.—Oh, yes.

28903. (*Sir William Ramsay.*) Then you said: "I think it would be fair to set up a common standard for all bleach works." I presume that this joint meeting would resolve finally upon a standard?—I had not that in my mind when I wrote this.

28904. But that would be done?—That would be the object of the joint meeting.

28905. Then again, you would have the standard for the effluent; not for the river necessarily, but for the effluent?—Yes, that would be the effluent.

28906. I suppose the reason why the Croal could not be made suitable for manufacturing purposes is the very large amount of solids turned in with bleach works effluent?—I should think the bulk of the solids could be taken out.

28907. Chiefly being lime?—The solids in suspension anyway.

28908. But the dissolved solids would be chiefly lime and starch?—Organic matter. I should not like to say anything is impossible, but it would take a great deal of purifying.

28909. I want to ask about the suspended solids The suspended solids can all be removed in the settling, but do you think that the solids in solution could also be removed?—I think it breaks up to some extent.

28910. It gets precipitated along with the solids?—I mean to say, if you take a bottle filled with ordinary liquor, it looks comparatively clear at the time, and if you keep it, after a while it certainly settles out.

28911. And you think it removes with it the substances in solution to some extent?—Yes, and I think the filter beds also break down a good deal of those elements in solution.

28912. (*Sir William Power.*) (*In the Chair.*) The Commission are much obliged to you for the evidence and the assistance you have given, and are giving.—They are very welcome, Sir.

Mr. WALTER LEACH, F.C.S., Bradford, Yorkshire, representing Woolcombers, Limited, and Mr. HAROLD MARSHALL Solicitor, Halifax, representing Woolcombers, Limited, called in; and Examined.

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28913. (*Sir William Ramsay.*) (*In the Chair.*) We are very much obliged to you for coming to help us in this inquiry. I should like to ask first if you will allow this evidence to be printed? It might save time if it went on our Minutes at once, and I could supplement it by putting questions, and no doubt the other members of the Commission would do the same.—(*Mr. Leach.*) Yes, certainly.

Walter Leach, Fellow of the Chemical Society, has had an extensive experience in the treatment of trade effluents extending over a period of twenty-five years. Is Consulting Chemist and Engineer to Woolcombers, Limited, Bradford.

The Woolcombers, Limited, carry on an extensive business as woolcombers at twenty different branches, situate in the West Riding; in Bradford, Shipley, Halifax, and elsewhere.

Question 1.—Upon what principles should the Commission proceed in framing recommendations as to the extent to which a manufacturer should be required to purify his trade effluents before discharging them into a river or stream?

I have read the evidence of Mr. Harold Marshall on this question, with which I concur.

Question 2.—Should there be fixed standards for various trades, and, if so, should the law provide means by which the standard could be raised or lowered according to the character of the stream?

(*a*) Fixed standards would be preferable, particularly when the effluent is discharged into a stream.

(*b*) In considering the question of standards, regard must be had to the fact that in each class of industry, and in particular in the woolcombing industry, the effluents to be treated depend upon the class of material treated and the particular process involved at the moment, and show a very wide variation from hour to hour and from day to day.

(*c*) It follows, therefore, that a fixed standard to be practicable must be fixed in each class of industry on the basis of the effluent resulting after approved treatment from the material or processes containing the maximum ingredients in the class of industry affected.

(*d*) The authority may be empowered to vary or dispense with a standard from time to time as improved methods of treatment of the effluents from any particular class of industry become known or a proper case made out.

(*e*) It would be impracticable to comply with a standard on the basis of the character of a stream.

(*f*) The standard must be on the basis of the character of the class of industry affected.

(*g*) A woolcomber on stream A could not do better than a woolcomber on stream B, simply because of the higher character of the stream. Each must be controlled by the class of industry.

(*h*) When the stream is of any ordinary standard of purity the riparian owners may be depended on to prevent any new pollution from arising.

(*i*) With this reservation the stream should be subservient to the industries upon it, subject to a reasonable practicable standard fixed on the basis of the class of such industries. Otherwise the industries will suffer.

Question 3.—What methods are available for purifying trade effluents of various sorts within reasonable limits of cost, and what is the character or quality of the purified effluents produced by such methods?

(*a*) In my opinion, speaking for woolcombers' effluents, these effluents must be classed as absolutely different from ordinary cloth and woollen scouring effluents. The chief difference lies in:—

(1) The presence of emulsified wool fat.

(2) The high percentage of dissolved organic matter.

(3) The strongly alkaline nature of the liquors.

(*b*) The class of wool washed varies greatly. English, Scotch and Irish wools contain traces only of wool fat and potash. Botany, Australian, New Zealand and Buenos Ayres wools contain 15 to 25 per cent. of wool-fat, 6 per cent. of carbonate of potash, and up to 20 per cent. of sand, and generally yield only 40 to 50 per cent. of clean scoured wool, the whole of the remaining impurities going away with the wash waters.

(*c*) The present system of treatment adopted by Woolcombers, Limited, (which is on the most improved known principle) consists of:—

(1) Running the wash waters into sand-settling ponds, where a large quantity of solid sand and earthy impurities settle out.

(2) Cracking with sulphuric acid the partly clarified suds.

(3) The grease resulting from the neutralisation of the alkali of the soaps used, together with the wool fats and some remaining earthy matter, rises to the surface of the cracking tanks, and is then drawn off on to magma filters, through which the water drains away, leaving the greasy magma as a semi-solid mass, which is made up in canvas bags and pressed in a steam heated hydraulic press.

(4) The acid effluent from the magma separation is run into a catch tank, where a further separation of grease takes place, and the final effluent is then run on to cinder filters, from which it is discharged to the river.

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(*d*) I have, from time to time, made experiments with this final effluent with a view to further possible purification of such effluent, but have always found that the resulting effluent is unsatisfactory.

(*e*) I have, within the last three months conducted special experiments on the final effluent on a comparatively large scale, using 40-gallon samples of the effluent as now discharged in each case.

(*f*) These experiments have been made at the Charlestown Works, Shipley, of Woolcombers, Limited. From these works the effluent is discharged into the River Aire at a point below the outfall of the Bradford Beck.

(*g*) The following is the result of such experiments:—

(1) The total volume of effluent is 200,000 gallons per week (night and day running), making 50 to 60 tons of magma, yielding 5 to 6 tons of grease.

(2) The untreated effluent from the washing bowls has the following compositions:—

	Parts per 100,000.
Total solids - - - -	5,000 to 6,000
Organic matter - - -	3,000 „ 3,800
Mineral matter - - -	2,000 „ 2,500
Fats - - - - - -	1.300 „ 2,500
Alkalinity equals H_2SO_4 -	600 „ 800

(3) The effluent after treatment as above, has an average composition of:—

	Parts per 100,000.
Total solid matter - -	1,700 to 2,000
Organic matter - - -	800 „ 1,000
Mineral matter - - -	900 „ 1,000
Fatty matter - - -	400 „ 500
Acidity as $H_2\,SO_4$ - -	171

(*h*) (1) A 40-gallon sample of this effluent was treated by neutralising with lime (4½ lbs), and precipitating with alumina ferric (4 lbs), and gave 44 lbs. of press cake of the following composition:—

	Per Cent.
Water - - - - - - -	66·68
Organic matter - - - - -	10·44
Mineral matter - - - - -	22·88
Fats - - - - - - -	2·0

(2) The effluent from the above-tested as under:—

	Parts per 100,000.
Total solids - - - -	1623
Organic matter - - -	245
Mineral matter - - -	1277
Fatty matter - - -	17·6
Alkalinity as CaO - -	154

Being a reduction of:—

	Parts per 100,000.
Total solids - - - -	351
Organic matter - - -	627
Mineral matter - - -	276
Fatty matter - - -	417

(*i*) This treatment would produce, roughly, 1 lb. of press cake per gallon, so that nearly 90 tons would be produced per week, requiring 9 tons of alumina ferric, (£3 10s.) per ton, and 10 tons of lime (£1) per ton:—

	£	s.	d.
Costing - - - -	31	10	0
	10	0	0
	£41	10	0 per week,

or over £2,000 per year for chemicals alone. The cost of pressing, and of press cloths must be added, and also the cost of disposal of the sludge, so that the lowest estimate of cost of treatment on that basis at Charlestown Works, would, in my opinion, amount to at least £4,000 per year, which would be impracticable.

(*j*) In my opinion there is no known system of precipitation which will treat satisfactorily at other than a prohibitive cost such an organically impure liquid as wool-washing suds.

(*k*) With regard to the evaporation treatment, I some years since designed a special process for the treatment of wool-washing suds by evaporation, which was patented under the names of John Smith & Sons, of Bradford, and myself.

(*l*) This process was worked continuously at Field Head Mills, Bradford, for seven to eight years, treating the effluent from two sets of wash bowls discharging about 2,500 gallons per hour. When this mode of treatment was applied to Australian wool, specially rich in grease and potash salts, the sales of these substances together with the saving in cost of soap by using distilled water repaid the users for the cost of working.

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(*m*) The system cannot be applied to commission wool scourers' requirements, as the class of wool washed varies within very wide limits.

(*n*) The cost of the treatment at present adopted at most of the works of Woolcombers Limited, results in a nett loss to the Company.

(*o*) In my opinion, the only method available for purifying woolcombers' effluent within reasonable limit of cost is that known as "the acid treatment," the most improved form of which is now carried out at the works of Woolcombers, Limited.

(*p*) The quality of the purified effluent produced at the Charlestown Works is as already given by me.

(*q*) There are no methods available for further purifying the purified effluent within reasonable limits of cost. I base my opinion on the following grounds:—

(1) The enormous volume of liquor and high percentage of organic impurities present make precipitation of the final effluent commercially impracticable on the ground of expense.

(2) The large quantity and difficulty of disposal of the sludge which would become a nuisance wherever it were tipped.

(3) The large area required for the necessary plant (more than double the present space of the system in use). The nuisance arising from the smell.

(4) The alkalinity of the resulting effluent which would be more liable to putrefaction and to cause a nuisance as distinguished from the present acid effluent which does not readily do so.

Question 4.—Whether there are any cases in which manufactures experience difficulty in satisfactorily purifying or disposing of trade effluents.

The purification and disposal of woolcombers' trade effluent present serious difficulties.

Question 5.—Whether any alterations of the law are desirable in regard to trade effluents and manufacturing pollutions generally.

I have read Mr. Harold Marshall's evidence on this question, with which I concur.

Harold Marshall, Solicitor for Woolcombers, Limited; Secretary of the Halifax Traders' Committee.

Question 1.—Upon what principles should the Commission proceed in framing recommendations as to the extent to which a manufacturer should be required to purify his trade effluents before discharging them into a river or stream?

1. The rights of riparian owners should not be interfered with.

2. (*a*) Regard should be had to the industrial interests involved, and to the circumstances and requirements of the locality, necessitating, amongst other considerations, the nature of the district (whether industrial or otherwise) through which the river flows, and the conditions, mode of user, and volume of the waters thereof.

(*b*) The court or authority having jurisdiction should be satisfied in each case by proper evidence that, under all the circumstances, means exist at reasonable cost for treating the effluent and are reasonably practicable and available without causing material injury to the industry affected.

3. Subject to 1 and 2, the manufacturer should use the best practicable and reasonably available means to comply with a standard of purity applicable to the class of industry affected, such standard to be fixed on the basis mentioned by Mr. Leach in answer to Question 2.

Question 2.—Should there be fixed standards for various trades, and, if so, should the law provide means by which the standard could be raised or lowered, according to the character of the stream?

I concur in the evidence of Mr. Leach on this question.

Question 3.—What methods are available for purifying trade effluents of various sorts within reasonable limits of cost, and what is the character or quality of the purified effluents produced by such methods?

See evidence of Mr. Leach.

Question 4.—Whether there are any cases in which manufacturers experience difficulty in satisfactorily purifying or disposing of trade effluents?

I concur with the evidence of Mr. Leach on this question.

Question 5.—Whether any alterations of the law are desirable in regard to trade effluents and manufacturing pollutions generally?

1. (*a*) In my opinion speaking generally, any alteration of the law should proceed on the basis of my answer to Question 1.

(*b*) In particular, the sewers of a sanitary authority should not be deemed sufficient for the requirements of their district, unless such sewers are sufficient to receive and dispose of trade effluents within the sanitary area, and Sec. 7 of the Rivers Pollution Act, 1876, should be amended accordingly.

(*c*) The term "sewers" in the 1876 Act should be defined to include outfall works in view of the decision of the Court of Appeal in *Brook* v. *Meltham Urban District Council*, 1908, 2 K.B. 780, since affirmed by the House of Lords.

(*d*) The sanitary authority should be compelled to receive into the sewers and dispose of trade effluents, subject to reasonable conditions as to preliminary treatment or payment.

(*e*) Any outlay to comply with such conditions or payment required to be made by the manufacturer, should be allowed in the assessment of the net annual value of his trade premises for rating purposes.

(*f*) The terms "manufacturers" and "manufacturing" in the Rivers Pollution Prevention Acts should be defined to extend to every industry involved.

(*g*) The following enactments should apply to manufacturing and mining pollutions as well as to sewage matters:—

Par. 5 of Part II. of the Rivers Pollution Prevention Act, 1876.

The Rivers Pollution Prevention Act, 1893, Sec. 1.

(*h*) The West Riding Rivers Act of 1894, Sec. 11 (2) and (3), should be altered so as to accord with the 1876 Act, Sec. 6 (Pars. 6 and 7).

(*i*) The West Riding Rivers Act, 1894, should contain a similar power to Sec. 8 (Par. 3), of the 1876 Act, and Sec. 18 of the 1894 Act should be amended accordingly.

As to Procedure.

2. (*a*) A Central Authority is recommended by the Commission and if appointed would appear to be a convenient authority to deal with disputes between the manufacturers and the Rivers Board, failing agreement to refer to an arbitrator, subject to a right to have any question of law involved decided by the Court.

(*b*) Any Authority which is to command the confidence of the parties must be entitled to have the case properly heard. This can only be done by the parties being entitled to be legally represented and to adduce such evidence as they may be advised is necessary.

(*c*) In every case the authority having jurisdiction should state the grounds for their decision on the same lines as a Judge.

(*d*) A manufacturer should be entitled to reasonable notice before proceeding against him. Manufacturers should be entitled to obtain an Order from the Central Authority to vary or dispense with a standard for good cause shown at any time.

(*e*) Under the present law the West Riding Rivers Board may proceed before the magistrates under their 1894 Act, and before the County Court under the 1876 Act.

(*f*) The effect of these alternative procedures is to give to the Rivers Board the option of selecting their tribunal in each case, which is unsatisfactory.

(*g*) Whatever the authority, there should be one procedure applicable to all parties, with the right of appeal on any question of law.

(*h*) I am unable to concur in the views expressed by Mr. Atter and Dr. Wilson as embodied in the statement handed by them to the Commission (Q. 27167)

New Source of Pollution.

3. (*a*) I do not think special legislation which does not apply to an existing business is necessary or desirable in the case of a new business. Q. 27167, Q. 27180, Q. 28406, Q. 28408.

(*b*) Any person starting a new business which contains polluting element may be assumed to be well aware of his responsibilities in regard to rivers, and will have made his plans accordingly.

(*c*) There can be no reason for placing him on a less favourable footing than anyone else by imposing on him a special penalty as suggested. Q. 27167.

(*d*) When a man is prepared to risk capital in a new business he should have every encouragement.

(*e*) Notices from the public authority of penalties which he will lay himself open to if he commits a breach of the law are unnecessary.

(*f*) The course suggested by Mr. Atter and Dr. Wilson on this head in my opinion is unnecessary and inexpedient and might lead to misunderstanding and cause the capitalist to abandon the intention of embarking his capital in the business at all which would mean a substantial loss to the district.

27180. (*g*) The fact of the Rivers Board having been in active operation since 1893 without having found it necessary to consider this question infers that no grievance exists.

ABUSE OF PURIFICATION WORKS.

27167. 27184 –27188. 4. (*a*) I do not agree that any difficulty arises in dealing with this question under the present law.

(*b*) Such a case must be exceptional or the matter would have been brought before the Court either under the 1876 Act or the 1894 Act.

(*c*) If the facts were as stated on a first offence a warning would be sufficient. If the offence were repeated the master would probably be convicted under the present law.

SHORT TENANCIES.

27167. 27189 –27200. 5. (*a*) The effect would be that the owners would not let under such terms.

(*b*) The owner would not lay down the capital and the tenant would not be tied, and the place would stand empty.

(*c*) The owner of the premises has no interest in the business of the tenant. The tenant makes his own arrangements for his own business and would resent interference from the landlord in regard thereto.

(*d*) The tenant's operations might necessitate alterations in the mode of dealing with his trade refuse at any time.

(*e*) The owner would not accept responsibility, it would pay him better to keep the premises unlet.

(*f*) Short tenancies must be exceptional and can only apply to small premises.

(*g*) The case of the dyehouse weekly tenancy (Q. 27189) must have been very small and most exceptional and does not need special legislation.

27190. (*h*) The Rivers Board could have applied for a penalty under the 1894 Act. They evidenlty did not do so. If they had done so they could have followed him.

27195. (*i*) The traders are fully aware of their obligation to prevent pollution and when they take any premises they are prepared to accept the same.

(*j*) This obligation is fully considered by both parties on arranging terms of tenancy.

(*k*) A tenancy nominally for three years does not imply a tenancy limited to three years. (Birstall case.)

(*l*) It generally means that if the tenant considers the place suitable for the business the tenancy will continue.

27196. (*m*) The powers of the Rivers Board are undoubtedly universal knowledge in the West Riding amongst traders.

27198. (*n*) I have not seen any agreement containing such a term as is mentioned in 27,198, but it does not appear unreasonable.

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(*o*) The tenancy to which such term is applicable must be very small.

(*p*) A tenant does not take a premises and lay down any substantial capital therein on such a basis.

(*q*) I would point out that if such a case occurred the Rivers Board could apply for a penalty against him under their special Act which would be ample protection. They, however, appear to prefer to adopt the 1876 Act. This alternative procedure is unsatisfactory. Q. 27199.

LIQUID REFUSE DEALT WITH BY CONTRACTOR.

6. (*a*) Here again there should be no difficulty in ascertaining the liability of the mill-owner or the contractor, or both in each individual case, and punishing him if the proper procedure is taken. Q. 27167. Q. 27201 –27204.

(*b*) The powers of the Rivers Board are ample for the purpose. Rivers Board Act, Secs. 11 and 12.

(*c*) If desired to make more clear, the onus might be placed on the party proceeded against in the absence of evidence of agreement to the contrary.

(*d*) The refusal of the Local Government Board in the Colliery case was an exercise of their discretion on the particular facts of that case, showing importance of discretionary power. 27249 –27253.

(*e*) The Rivers Board can proceed under the Rivers Board Act, 1894, or the Rivers Pollution Prevention Act, 1876.

(*f*) If they go under the Rivers Pollution Prevention Act, 1876, the penalty is incurred when the Order of Court is disobeyed; if they go under the Rivers Board Act, 1894, they can apply for a penalty in the first instance with or without further relief. It is simply a question of procedure. This alternative procedure is objectionable.

SAMPLES.

7. (*a*) The manufacturers do not in my experience object to the Authority obtaining samples on the premises if approached in an open manner. Q. 27167.

(*b*) I have inquired into the Halifax illustration referred to, which appears to have been an isolated case and arose from a misapprehension, which was put right some time since. I am informed the Rivers Board Inspectors have since been accustomed to visit the premises whenever they wish without interference. In my opinion the Board have ample powers under their local Act. Q. 27239.

(*c*) It would be impossible to change the character of the effluent in the mode suggested without stopping the business. Q. 27241. Q. 27242.

(*d*) The main objection of the manufacturer in regard to samples is not so much the principles of the Rivers Pollution Prevention Acts, if worked out on reasonable lines.

(*e*) Samples should be taken openly and one half part should not be taken away but should be left with the person in charge of the premises properly sealed and with particulars of the date, time and place of taking and the name and description of the person taking. Any disturbance of the surface should be made good by the Authority.

(*f*) If this course is adopted, objection would not be raised by any reasonable man.

28914. I will take it in order; we will leave the joint question till later. I think, Mr. Leach, in your very first statement you say: "Fixed standards would be preferable, particularly when the effluent is discharged into a stream." Have you got any such fixed standard in your mind?—It is dealt with in reply (*b*) to the question. The standard will have to be based, in my opinion, on the particular effluent which is turned out when the worst class of material is being treated in the particular works under the conditions of treatment.

28915. I do not quite follow. Would you take the very worst class of material that you have to treat? You would treat that as well as it could be treated; you would then apply the standard to the effluent which is obtained by such treatment?—That is so. In my opinion, that is the only practicable standard which may be set up. The nature of the wool treated is so different at different times, and that we cannot regulate.

28916. But could you not save up that effluent in tanks so as to make it uniform?—Well, one lot of wool might run on for one day, ten days, three weeks or six months. The variation of each lot of wool is our difficulty with regard to storage.

28917. I see!—At certain of our works we deal with wool which remains the same in quality for three months at a time; that is to say, the lot of wool is never broken out or stopped. In other words, we have to accept any parcel of wool, of whatever weight, which any customer sends us, and sometimes those parcels are bad samples of very bad lots, and they run perhaps for an hour. In a case like that we do store. We store about twenty-four hours' supply, but in most cases we could not store above a day's supply.

28918. Where the treatment goes on for a long time?—Where the treatment goes on for a long time.

28919. Why do you think it would be impracticable to comply with a standard on the basis of the character of a stream? No doubt if you turn a poor effluent into a large stream, it does not produce very much effect. On the other hand, if it goes into a small stream the effect is serious?—Yes.

28920. But would you not regulate it by the size of the stream, or is the variation in the size of the stream an objection?—If you fix a standard in proportion to the stream you place one manufacturer at a disadvantage compared with another. A manufacturer situated on

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a large stream would have to do a small amount of purification compared with one on a small stream.

28921. (*Dr. McGowan.*) If you buy a house in London, you pay more for it than you would pay in the country.

28922. (*Chairman.*) That gives an analogy. Dr. McGowan says if you buy a house in London you pay more for it than you pay in the country; it is a natural advantage. You probably pay more for the proximity to that large stream than you would to the small one?—Certainly.

28923. There is something to be said for that point?—Yes, that is so.

28924. Under letter (*h*) you say: "When the stream is of any ordinary standard of purity"; that means when it is not polluted I presume?—When it is not polluted by trade refuse.

28925. Or by sewage?—Or by sewage.

28926. Wool fat, I suppose, means emulsifiable wool fat?—Yes.

28927. Suint?—No, not suint. I would not include that as wool fat. It is the emulsifiable grease which is wool fat. Suint is a solution of peculiar organic salts of potash.

29828. It is largely emulsified wool fat?—It is largely emulsified wool fat, but suint is the name applied to the liquor from steeping greasy Botany wool in cold water for the recovery of Potash.

28929. And the impurities go away with the wash waters from the wools, which contain a very large amount of wool fat? You say the whole of the remaining impurities are chiefly sand?—Sand and organic potash salts.

28930. They are allowed to go?—The organic potash salts are allowed to go. The sand is kept back.

28931. You do not try to save those?—We do not try to save those.

28932. Are they not profitably saved in France?—They are in France, but there are peculiar conditions which obtain here which do not obtain in France. In France they deal with one class of wool, Australian or Buenos Ayres wool. In Bradford we treat various kinds of wool, and it has not been found profitable. We have several of our works fitted with potash recovery plants, but they have every one been abandoned because of the expense.

28933. Because of the irregularity of the supply?—Because of the irregularity of the supply and the large amount of evaporation which has to be done in order to recover the potash. In France the solutions are got up to 8 per cent. of carbonate of potash. In Bradford, in the case of the wools we treat, it is not even 2 per cent. That means there is eight or ten times the evaporation to be done.

28934. And these potash salts, with their very dirty-looking acids, I suppose go away?—Yes.

28935. The organic matter mentioned under the heading (*g*) too, I assume, are those potash salts we were speaking of?—Yes, Sir.

28936. They are differentiated from the fats in that way. Have you ever tried septic tanks as a means of treating such effluents after the fats have been removed?—No, Sir, we have not.

28937. It might be possible to make it undergo anaerobic fermentation?—Yes, it might be possible. We have never tried any experiments on those lines at all.

28938. As an answer to Question 4 you merely state that: "The purification and disposal of woolcombers' trade effluent present serious difficulties." Have you no suggestion to make except cracking the fats, actually what you at present do?—There are only two processes which are available in my opinion. One is the removal of the fats and the filtration of the resultant effluent, and the other is evaporation.

28939. After removal of the fats?—After removal of the fats, prior to evaporation.

28940. You do gain on the recovery of fats, do you not, on the whole?—No, the net result to our Company is a loss, owing to the very low price to which grease has fallen.

28941. Is it probable it will rise again?—It is very unlikely. The Bradford Corporation at their Sewage Works are recovering very large quantities of fat, and that has depressed the market considerably. Where we formerly got £13 to £14 per ton for the grease, we are now only getting £6 10s. to £7, and it costs very closely on to £7 per ton to produce it—the working cost. That is not including the rent of the land or interest on the plant.

28942. But in spite of doing that you still have a very seriously polluted effluent to dispose of afterwards?—That is so.

28943. Then, taking up the question of evaporation, is not that feasible?—It would be feasible if one class of wool were dealt with. It entirely depends on the proportion of grease and carbonate of potash which would be recoverable.

28944. But after evaporation you would remove the grease; you would crack it?—No, we do not crack it; we remove it by centrifugal action.

28945. But that is not saponifiable fat, is it?—That is not saponifiable; about 20 per cent. is saponifiable, the remaining 80 per cent. being non-saponifiable.

28946. Is that what you squeeze out by hot presses?—It is rather a different fat which is recovered; there are no fatty acids in it. It is quite a neutral fat. In the fat we recover by acid treatment we get anything from 16 to 25 per cent. of fatty acids.

28947. Are both those classes of fat used for the same purpose?—No, quite different purposes. They are both used for currying leather; that is the only common purpose to which they are put.

28948. Is one not used for greasing the wool in spinning?—No, it is too thick for that purpose; only olive oil is used for greasing wool in spinning.

28949. What is it used for mostly?—To produce oleine and stearine. Stearine is used for leather currying, and oleine is used for lubricating shoddy in the Batley and Dewsbury districts.

28950. But as a matter of expense, would it not pay you to get rid of the whole of your effluent by evaporation? It is going to cost something; is not this the cheapest way of getting rid of it? You do make something on the potash; you do make something on the fats?—If there is potash and fat to begin with. The Bradford trade during the last ten years has changed materially in regard to the character and the quality of the wool used in it. Formerly only Australian and Buenos Ayres wools were used. Now we get scoured wools imported from Australia, in order to save the carriage of the weight of grease, &c., which is about 50 per cent grease and other matters. The cost of carriage is a very considerable item, and in order to do away with that, we have imported, for some years past, a large quantity of scoured wool.

28951. There is also another element which enters into it; that is the skin wool—wool which is taken off the dead pelt of the sheep. Is that more liable to be dirty than the other?—It contains no grease, or practically no grease, and no potash.

28952. But I suppose as a general principle you would say, in order to get rid of your impure liquors in some way or another, some expense must be borne?—Certainly.

28953. Then the question comes up, which process is most efficient and at the same time the least expensive?—Yes, Sir.

28954. You think evaporation is the best course to pursue?—It is undoubtedly the best solution of the difficulty, because you produce no effluent whatever.

28955. Has that been done?—Yes. I took out patents for that and put one plant up in Bradford, which dealt with 3,000 gallons an hour as a maximum. The average quantity dealt with was 2,500. The evaporation was done in a quadruple effect evaporator. And then we patented a special type of centrifugal machine, which would run continuously with the concentrated effluent. If you treat washing effluent immediately it comes from the washing pails in the centrifugal machine, you cannot get a separation of the fat, because the density of the fat is so near to the density of the solution it is contained in. But by increasing the density of the solution, and leaving the fat of the same density, you get a considerable difference, and that renders it possible to separate about 90 per cent. of the wool fat. This machine was run on the same principle as the ordinary centrifugal machine of the ordinary cream separator type, and the potash liquor escaped over a bevelled plate at the side. The back contained all the sand. These machines were run for about four hours at a stretch, and then stopped to have the sand cleaned out. The potash liquor which ran away contained about 16 to 18 per cent. of carbonate of potash, and was evaporated and run into a rotary furnace. The whole of the water which was distilled was recovered, and used as distilled water in the wash houses, and it resulted in a net saving of about 14 per cent. in soap.

28956. Was that a loss on the whole ?—There was a profit on those particular works of about £20 a week, as long as they were on the character of the wool for which the machine was put down.

28957. But taking it on the year, or period of years, would it be a loss or a profit ?—It would under present conditions be a loss, a serious loss, on account of the by-products not being present in sufficiently large quantity to result in a profitable return.

28958. But would you regard it as a legitimate loss ; I mean to say, as a loss which you could not help ? You have to produce some reasonable effluent or stop an effluent altogether, from the point of view of the works ?—It would lead to a very much enhanced cost of production, undoubtedly.

28959. If all your competitors were obliged to do the same thing, would it make much difference ?—We should have a very serious competition with the Continent under those conditions, in all probability.

28960. Where there is no such restriction ?—Where there is no such restriction.

28961. (*Sir William Power.*) Does the evaporation process deal with the whole of the liquid refuse in your works ?—Yes, the whole of it. There is absolutely no liquid goes away from the works. No nuisance can arise from it, unless the plant breaks down of course. This plant ran night and day for eighteen months without being cleaned out, or breaking down. So it was a thoroughly practical scheme. It is only the change in the character of the wool that has rendered that plant inoperative.

28962. (*Chairman.*) It looks irrevocable, because probably they will never go back to sending unscoured wool from Australia to this country ?—No, they will never go back to that now.

28963. (*Colonel Harding.*) Mr. Leach, you have said, in answer to Sir Wm. Ramsay just now, that if woolcombers were put to expense in treating their effluents, they would be at a disadvantage in competition with foreigners, who are not called upon to do anything ?—Yes.

28964. But is that so ?—That would be so undoubtedly.

28965. But are they not called upon to do anything ?—In Roubaix the whole of the effluent goes down to the river.

28966. Has not the shockingly impure condition of the river become rather an international question in France ?—Yes.

28967. And is not considerable pressure now being brought to bear on the manufacturers of Roubaix to do something ?—Up to now there is no treatment being pursued there.

28968. Are there no plans for dealing with these waters by means of carbon bisulphide, or benzine ?—There is one plant at Verviers. There is one on the American system at Verviers, which treats wool by petroleum benzine.

28969. Is it not a fact that there is a great deal of pressure being brought to bear on the French woolcombers in the Roubaix district to purify their effluent ?—There has been for the last fifteen years, but up to now without effect.

28970. Has nothing been done by any of them ?—There is the old Battage process and the acid cracking process ; they have these at Roubaix.

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28971. They have in fact carried out what you are carrying out ?—They have carried out the same system we are carrying out, precisely.

28972. Then without doubt, if some means were shown in that district for dealing with these effluents, those manufacturers in the Roubaix district would be called upon to do something on the same lines ?—Yes, possibly.

28973. So that the objection that you raised just now, that if you are called upon to carry out works you would be placed at a disadvantage with foreign competitors, would scarcely hold good ?—Provided they took up the same process, of course.

28974. Is it not extremely likely they would be compelled to do so ?—There would be pressure put upon them, certainly.

28975. (*Chairman.*) I think you made a remark before that they dealt with a different quality of wool ?—That is so.

28976. Therefore, they could work it at a profit ?—Therefore they could work it better than we could do at Bradford.

28977. (*Colonel Harding.*) Then you do recognise that it is necessary for manufacturers to incur some expense in dealing with their effluent ?—Certainly, if they become a nuisance ; most decidedly.

28978. You have spoken to us of your process at the Field Head Mills, which actually did give, under certain circumstances, a profit ?—Yes.

28979. Is the impracticability of that process in other cases simply due to the expense ?—Due to the expense only ; yes.

28980. Apart from expense it is practicable ?—It is a practical means.

28981. Then what sort of expense might be incurred say in the case of Charlestown Mills if such a process were carried out ? You have a Mill at Charlestown, and you have there a considerable volume of effluent ?—Yes.

28982. If you were called upon to deal with that effluent on the lines of Field Head Mills, what sort of expense would be incurred ?—The expense of coal for evaporation, boiler, plant for generating steam, and wages. Those are the only items. The chief item, of course, is the cost of evaporation.

28983. It would be very interesting to us to get an answer if possible to a question of that kind, because that is a process which is obviously a businesslike one, because it does away with the effluent altogether ?—That is so.

28984. Is there any necessity at your Charlestown Mills for you to return to the river the water that you take from the river ?—No, we do not take any water from the river for our washing.

28985. Then there would be no difficulty as regards riparian owners in carrying out your process of evaporation ?—There might be a difficulty in one sense ; the evaporation is conducted in vacuum, and the vacuum is obtained by a jet condenser worked from the river, and the distilled water which is produced contains large quantities of ammoniacal vapour, and also sulphide compounds, which might be objected to by the river people on account of the smell. At Field Head Mills we discharge into the sewer.

28986. Is the volume of that large or small ?—It is a very large volume, about twenty times the amount of the distilled water recovered.

28987. And it is not right to say the process of evaporation does away with the effluent altogether ?—It does away with effluent.

28988. But it produces a by-product which is worse ?—It is not worse. It is not anything like so serious an objection. It is simply the vapour, the gas, which comes away from distilled water, and is removed by the water used for producing the vacuum in the jet condenser.

28989. (*Chairman.*) There are no solids ?—There are no solids ; it is simply a gas and it smells. It is not really an objectionable smell, but it might be objected to in the river.

28990. (*Colonel Harding.*) Would it interfere with the use of the water by the manufacturers lower down ?—No, oh no ; it is only a smell.

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28991. It would not affect their boilers ?—No, it would not affect their boilers.

28992. Would that smell pass off readily as the water passed down the stream ?—Oh yes ; it passes off very readily.

28993. Then you do not say that the process of evaporation owing to this discharge would be objected to ?—I do not think so ; the whole of the smell can be dissipated from the water by blowing air through it.

28994. The difficulty can be got over ?—Oh, yes.

28995. Then the whole question turns upon the point of expense ?—That is so.

28996. And you are unable to tell us what the expense would be in the case of your Charlestown Mills ?—I could not tell you from memory ; I could get the figures out for you.

28997. (*Chairman.*) The expense would vary with the class of wool you are treating ?—It varies with the quantity of water you evaporate.

28998. (*Colonel Harding.*) What is the volume of the water you deal with there ?—About 1,800 gallons an hour, day and night.

28999. It would be considerable ?—Yes.

29000. The cost of evaporation ?—You can evaporate 25 lbs. of water per 1 lb. of coal. Our figures vary between 23 and 28 ; we will take it at 25.

29001. Would it be possible for you to give us any information as to what might be the cost of evaporation in a specific case like that of your Charlestown Mills. I do not suggest to you, Mr. Leach, that it is financially practicable but it would be interesting to us to simply have that information ?—I could let you have that information in a couple of days.

29002. I do not want you to do it immediately ?—I could give you roughly an idea.

29003. It would be interesting to us to know what such a process might cost. You might add it as a footnote to your evidence later on ; do not trouble to calculate it now because I know it would be very difficult for you to do so ?—Yes.

29004. Then with regard to some of these other solvent processes, have you considered at all what might be the cost of them ?—Yes, I have had some experience of solvent washing. The difficulty in a town lies in the danger in the first case of using large volumes of volatile solvents near large factories is the risk of explosion. That has been minimised to a considerable extent ; so much so that for twelve or fourteen years past the plant has been used in America by the Arlington Mills Co., and has run continuously during the whole of that time without any accident.

29005. What would they use ; common bi-sulphide ?—No, they use petroleum-naphtha.

29006. And is that for dealing with precisely the same class of wool ?—That would deal with any class of wool, irrespective of the grease contained in it.

29007. What experiments, if any, have been made in your district with that operation ?—There have been no experiments made in our district except by Messrs. Isaac Holden's. They experimented with bi-sulphide of carbon. That is liable to explosion. They had two serious explosions, and finally abandoned it on account of the danger of explosion.

29008. No experiments have been made with the solvent used in the United States ?—Only on a small scale.

29009. By whom ?—I had some experiments conducted in the Arlington Mills on several bales of wool which were treated half there and half on our ordinary system, as at Bradford, and the wool specialists, to whom the washed wool was submitted afterwards, declared unanimously that the system in use in Bradford was very much better for the purpose of the Bradford trade, than the American system. The Bradford system leaves in the fibre about ·6 to ·7 per cent. of the wool-fat and that has a marked effect on the spinning property of the fibre in Bradford. In America the whole of the grease is taken out, there is none left in the fibre, and that, in the opinion of the wool experts in Bradford leaves the fibre brittle and renders it less spinnable. The wool fibre flies in spinning more than it does with the Bradford system, and does not leave as soft a yarn. This has to my knowledge only been adopted by one firm in America, that is the Arlington Mills Co.

29010. So that that process, apart from the question of expense, you say is objectionable, because it makes the results, in regard to the fibre to be treated, worse ?—That is so. There is also another objection to it, that you have an effluent to deal with even in that case, because the wool, after it is de-greased, has to be washed in order to remove the salts of the potash and the organic impurities as well as the sand. You then have that effluent to deal with.

29011. We come now to the processes which are in actual use in your own mills, but before doing so I should like to ask you ; you have I believe twenty mills to superintend ?—Yes.

29012. And in regard to sixteen of them the difficulty disappears because you are connected with sewers ?—That is so.

29013. And why are not the other four connected with sewers ; are the circumstances impracticable ?—They are out of the town and there are no sewers near the works.

29014. Does that apply to the Valley Mills ?—To the Valley Mills, yes.

29015. Are there no sewers there ?—There are no sewers there. You mean the Valley Mills ; the Charlestown and Shipley, I presume.

29016. No, I mean the Valley Mills in Bradford ?—The Valley sheds.

29017. Yes ?—We are connected there with the sewers.

29018. You are connected now with the sewers ?—We are connected now with the sewers.

29019. Then you have only four mills which are not connected with the sewers ?—That is so.

29020. Do you suggest to us that the natural issue out of all these difficulties is to connect with the sewers ?—That would be the most practicable, certainly.

29021. Then somebody may have to fight out the difficulty ultimately with the local authority ?—It is fought out now in the Bradford Sewage Works very satisfactorily in regard to the recovery of grease, but there is no purification of the effluent after the fat has been taken out ; all the organic impurities originally present are still in with the exception of grease.

29022. Have you any experience of the effluent produced at the Frizinghall Works ?—I have only seen it ; I have never made any experiments with it.

29023. You do not suggest it is very satisfactory ?—It is not satisfactory by any means. It contains all the organic impurities which are putrescible.

29024. It is very bad indeed ?—It is very bad.

29025. When you speak of it as very satisfactory you mean as regards the extraction of grease ?—That is so only. It is very strongly acid on most occasions.

29026. The same thing applies, of course, to your carrying out that process in separate works ?—That is so ; you must have an excess of acid in order to have the grease separated.

29027. Now we will come to the process which you have in operation at your works, which are not connected with the sewers. You there extract the grease as far as it is practicable or as far as it pays to extract it ?—As far as it is practicable.

29028. Whether it pays or not ?—Whether it pays or not, yes.

29029. And at the present moment you tell us that, owing to the great production at the Frizinghall Works, the price to be obtained has been considerably reduced ?—That is so.

29030. So that the process which before was worth carrying out is now carried on at a loss ?—That is so.

29031. After you have abstracted the grease you have really to deal with an effluent which is extremely foul ?—That is so.

29032. And has any method been found successfully to deal with it at all ?—We are experimenting now and we have got a lot of information on which the general conclusion had been founded that we reduce the organic impurities very materially but increase the proportion of mineral matter by the use of lime and alumina-ferric. The result of some of these experiments is detailed in my evidence. The effluent is still very foul, even after the purification effected has been so much as this. In my proof the figures are given.

29033. That is the series of experiments with small 40-gallon samples ?—Yes, that is so.

29034. But the results obtained in those experiments are not very satisfactory, are they ?—If you take effluent 3, the organic matter, as the liquid is now discharged to the river, varies from 800 to 1,000 parts per 100,000. That is reduced down to about one-fourth, to 245 parts (Par. 2). The mineral matter on the other hand has gone up about 200 parts and the fatty matter has gone down from 400 parts to 17·6 parts.

29035. Then what is the mineral matter ?—The mineral matter is largely sulphates of potash and soda.

29036. Still very objectionable ?—Well, they are not objectionable in themselves ; it is the sewage matter which is the chief objection ; the salts of soda and potash would not be objectionable I take it.

29037. (*Chairman.*) I suppose you do not know what these salts are ?—No.

29038. Are they very dark coloured ?—They are very dark coloured, yes.

29039. (*Colonel Harding.*) So that the results you obtained were very far from being satisfactory ?—Far from being satisfactory.

29040. And would scarcely warrant the considerable expense you have been to to obtain them ?—I do not think they would satisfy any reasonable man. In regard to the cost, of course, that is an enormous item in dealing with these large quantities of liquor.

29041. You have had large experience in these matters. Can you suggest to us some ways other than those to which you have called our attention for dealing with this matter ?—The only other way I could suggest would be experimental work undertaken with septic tanks.

29042. What do you foresee would be the advantage of using septic tanks ?—They would get rid of a large quantity of suspended matter.

29043. By decomposition ?—By decomposition in the septic tank.

29044. By settlement first and then to some extent by decomposition ?—Yes.

29045. (*Chairman.*) Before or after the removal of the grease ?—After the removal of the grease, yes. I do not think a septic tank would be workable without previous removal of the grease. I believe it has been tried. Mr. Garfield has experimented with it, and I believe he has not succeeded in dealing with it on account of the grease which chokes the filters up very quickly ; it makes them air-proof, so the grease would have to be removed first.

29046. (*Colonel Harding.*) That is applied to the septic tank ?—Filtration after septic tank.

29047. But so far as septic tank is concerned you would expect decomposition and therefore a continual reduction of septic tank matter ?—That is so.

29048. Would you expect a large reduction ?—I am not prepared to make any statement on that point, because I have not made any experiment.

29049. You are acquainted with the digestion that takes place in the ordinary domestic septic tank ?—Yes.

29050. You are reducing it very much ?—25 to 30 per cent.

29051. You would not think it reasonable to expect more, a dry effluent ?—I think it reasonable to expect more after the grease is taken out.

29052. And you think septic tank is one of the lines on which you might make an experiment ?—I think it might be undertaken with a reasonable hope of success.

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29053. What do you think of the method of filtration by biological filters ?—Our difficulty in filtration has been that if you leave a small quantity of grease in you choke your filters in a very short time.

29054. You think evaporation absolutely necessary to remove all grease ?—Yes.

29055. Are you aware of Garfield's experiment in the filtration of the effluent after the grease has been removed ?—Yes.

29056. In this experiment was the grease sufficiently removed from the effluent ?—In the small experiments, yes.

29057. And if I remember right, although the effluent was acid, there was considerable improvement by the passage through the filter ?—Yes, in certain cases the effluent comes out in an alkaline condition. Whether that alkali is due to the decomposition of the acids, or to the neutralisation of the acids by the material of which the filter is composed, I should not be prepared to say ; I should think the latter is the more likely.

29058. Then you have not carried out any experiments on those lines yourself ?—No, we have not. Our effluents are very much more foul than the Corporation effluent. When mixed with domestic sewage they get a much more perfect separation of grease than we do in our works.

29059. You realise the necessity that something should be done to prevent these very foul effluents going into streams ?—I do certainly.

29060. You say somewhere in your evidence that you look upon streams as subservient to the manufacture being carried on in the neighbourhood ?—I think that should be so.

29061. I hope you do not suggest that they are a provision of nature for carrying away the effluent from factories ?—In our present condition of knowledge I do not think it is difficult to put what I exactly mean. I think the streams ought, in the present state of our knowledge, to be regarded as subservient to trade until some improvement can be made by which is reasonably possible for the manufacturer to purify his effluent.

29062. But you agree that it is the duty of the manufacturer to make efforts ?—Certainly to make efforts.

29063. To prevent the turning out of a polluting effluent ?—Quite so.

29064. You have to deal in this trade of wool-combing with an extremely difficult effluent ?—That is so.

29065. Various efforts have been made to improve it and so far, without satisfactory results. You yourself, having had large experience of the business, have tried certain experiments without satisfactory result, except in the direction of evaporation, and whether that would be practicable or not from a financial point of view, you are unable at present to tell us but it seems that is a direction in which we should make enquiries, should we not ?—Yes.

29066. How is progress to be made ? It has been suggested to this Commission that the Commission itself might take up this matter and consider whether it might not be possible to carry out experiments by its own experts with the view of finding out some better means of dealing with these effluents finally. That would involve some expense ?—Yes.

29067. Your important Association, embracing something like twenty mills, is largely interested in the satisfactory solution of this question ?—Quite so.

29068. I do not know whether you, or Mr. Marshall, would be able to say whether the Association would be prepared to give, first, facilities to the Commission to carry out certain experiments, and secondly, to bear either all or part of the cost of the experiments with an assurance beforehand as to the extent of the cost to be involved ?—I think my Association will be prepared to consider that proposition in a reasonable way.

29069. I might just mention to you an instance where we have carried out experimental work ; that is in connection with distillery effluents in Scotland. In that case the Association of Distillers provided the plant and we provided the expert to work it, and to carry out analyses and report from time to time upon it, and the information that we have been able to obtain, we have reason to

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think, will be of great value to that trade. Something of the same kind might be carried out; I do not say that it will, I am speaking individually, but I suggest to you that it might be possible for the Commission to undertake what is confessedly a very difficult task, and we had a witness before us this morning who suggested to us that in his particular trade, he thought it would be of advantage if the whole of the traders came together and gave the Commission some assistance and some encouragement to deal with an effluent which in their case also was a very difficult one to treat. It suggests itself to me, that in the case of woolcombers, it would be well worth while for your Association to give us facilities and assistance to help them to meet this very great difficulty ?—I think I could promise that all facilities would be given, and that my own services would be given, but as to whether my own Company would be prepared to go to the expense, I should not like to pledge myself at present, without consulting the Directors.

29070. I quite understand; you could not do that without some sort of idea what the expense would be ?—Yes, quite so.

29071. But if the Commission did decide to take up this matter, they would be able to suggest to your Association what kind of expense would be involved by the experiment ?—Quite so.

29072. I should not think the expense would be large, because the experiment might be carried out on a sufficiently small scale not to involve any great cost ?—Quite so.

29073. (*Mr. Tatton.*) Mr. Leach, would this evaporation process be available for small works or only for large works; I mean to say, supposing it turned out to be a satisfactory treatment ?—It would be available for all sizes of works.

29074. For all sizes of works ?—Yes. The only difficulty in applying it to small works is that the cost of evaporation is proportionately greater. You could not fit up a quadruple evaporation plant on a very small scale; the cost per gallon treated would be much higher.

29075. You have small works as well as large ?—Yes, we have.

29076. You have not tried anything beyond the grease cracking process as regards precipitation, except that ?—No, that is the only one, together with lime and alumina ferric.

29077. You have no tanks down ?—Oh, yes, we have tanks down at all our works.

29078. You have tanks for the grease, but you have no tanks for the effluent after the grease has been extracted ?—No, we have no separate tanks for that.

29079. Would it not be possible to separate that large amount of matter in suspension ?—No, there is not much in suspension; after the grease is taken out, it is largely in solution.

29080. Is that so; then you would not have much to extract in tanks ?—It is all in solution. The suspended matter is all present in solution, after the grease is taken out.

29081. But is there not a good deal of dirt that comes from the skins and so on ?—That all comes out in the settling pond and the grease.

29082. With the grease ?—It comes out as a thick pasty mass which is filtered off on magma filters, and that contains no solid matter in suspension.

29083. Then the whole of your effluent goes through the grease tanks ?—Yes, the whole of our effluent goes through the grease tanks, and then through a catch tank for a further settlement with grease, and finally through filters composed of ashes, cinders.

29084. (*Chairman.*) Then, Mr. Marshall, I think we may allow this summary of evidence of yours to be printed ?—(*Mr. Marshall.*) Yes.

29085. You think that the best practicable and reasonably available means are the best adapted to fit the case ?—I think so, subject to complying with the standard. I think if a standard were available it would be of great assistance.

29086. On the lines of Mr. Leach ?—Yes. We went very fully into the question of standards in Halifax in connection with the Halifax Traders' Committee. Those were not in connection with the stream, but with the sewers. We had to consider the question of standards, and every trader on the Committee was desirous that a standard should be fixed, if possible. They referred the matter to three chemists specially to devise standards if they could do so for the various trades, but the difficulty was the changes of the effluent. The chemists came to the conclusion that Mr. Leach comes to in regard to this question, that if you take a standard at all it must be the standard of the effluent containing the largest ingredients of polluting matter. For the purpose of the sewer the Corporation did not consider it necessary to press for the standards.

29087. Did not consider it necessary "to press for the standards" ?—No. It was left more to the question of preliminary treatment, so we did not proceed with the standards.

29088. Well, is it not likely then that if this standard of Mr. Leach were adopted it would be a very low one indeed ?—It would depend on the trade. What occurs to me is that it would work out in this way. I have a minimum standard to work to; if I am on my lowest grade of material I have to turn effluent above the standard, but it does not necessarily follow that I am always on that grade, and on other grades my actual product would be better than the minimum standard.

29089. Is there not another way of looking at it, that the minimum standard is such an impure liquid that there is no need to purify ?—I do not think you will find it is so. I think Mr. Leach is of opinion that as the result of it having undergone the best practical treatment, the effluent is really not a great deal worse than an average effluent from another class of wool; I think you will find that that is so in practice when the best practicable treatment has been adopted with it.

29090. Then you answer Question 5 in full with regard to the alterations of the law. Would, under (*b*), your own case be hinted at as regards the insufficient size of sewers; are they usually of sufficient size ?—They are in Halifax. In Halifax we have absolute power to go into the sewers.

29091. Are you troubled with the necessity of returning to the river the water which you take ?—We are in some cases, but where our Traders return the water to the river they have to deal with that separately. They have to return a similar quantity.

29092. Which you take from other sources of supply ?—Yes, they would have to take it from the town; at any rate they have to keep up the river, and each of the manufacturers looks after that.

29093. (*Sir William Power.*) A manufacturer cannot get rid of that obligation to return the water under any circumstances ?—No, and I do not think that any manufacturers suggest that they should be freed from that obligation. I think, as far as my experience goes, manufacturers generally are all of one mind, that if they take the water from the river they must return it.

29094. (*Chairman.*) Of course, if others do not do it, it hits them too ?—It is common ground, I believe.

29095. (*Sir William Power.*) If sewers are available to a given manufacturer he cannot, even with the consent of the authority, get out of his obligation to return, to the river, water that he has taken from the river; he must discharge an amount of water into the river equivalent to that he takes from it ?—That is so.

29096. He will have to find the water, even if he makes use of the sewer ?—Yes, that is so; that is an obligation which he ought to bear.

29097. (*Chairman.*) Your answer to Question 6 rather surprises me. What exception is there to the use of the terms manufacturer and manufacturing, as regards industry ?—Well, I have found in practice that "manufacturer" does not embody all industries—you might take just one instance; take a wool washer, who simply takes the wool and washes it. We do not call him a manufacturer. If you use a stream, in the 1876 Act there are other cases, viz., Sec. VI. Cl. 5 speaks of the seat of a manufacturing industry. Now, if it is a manufacturing industry, what is an industry which is not a manufacturing industry? What does it embody?—it is really a question of definition—all industries. It is just the question which was fought the other day on the meaning of "sewer," over again. It is to save litigation of that nature; to have defined what everybody means when he says "manufacturing industry" if you put it into the Act.

29098. It is not defined?—It is not defined.

29099. I see the point?—That is the reason why we in Halifax use the term "traders." That is really to get over the manufacturing difficulty; the term "traders" is used for that reason.

29100. In your answer (2) (*a*), as to procedure, do you think that before reference to a Central Authority a reference to an arbitrator should be had?—What I think is this, that as manufacturers we look upon the Rivers Board more as a policeman, and what we think is this, that if there is a difference between the Rivers Board and ourselves, frequently we should be able to meet together, as we do in other disputes, and say: "Well, now, you say that is so. According to our experience it is not, but there is so and so in whom we have every confidence. If you think the same we are quite willing to take his opinion upon it." And that settles the whole thing. That is what we mean by "failing an arbitrator," or "failing a reference," or "failing agreement," in effect. Then if we cannot agree, we think the Central Authority or the Local Government Board should decide between us. I think the general feeling, as far as my experience goes amongst manufacturers, is that the Rivers Board should be an administrative authority pure and simple.

29101. And not have judicial powers?—No, that creates a lot of friction. It is always felt to be unsatisfactory, and, whatever the result to one side, the other side always seems to be dissatisfied.

29102. Would you object to a Central Authority having further powers; it is at a greater distance; it has no axe to grind?—I think any question might come to the Central Authority if it is a question between the Rivers Board and the traders. I think that is a question which might be settled by the Central Authority with satisfaction to both parties.

29103. As a matter of fact, do you often have to appoint an arbitrator?—Well, no, we took power in the Halifax Act of 1905 when we were dealing with this question, and under that Act there was power to settle any dispute, and there is to-day in Halifax. In a dispute between the Corporation and the traders we have the power to go to an arbitrator, and if we do not agree upon an arbitrator then we can go to the Local Government Board. The fact of our having agreed to that has enabled us to come together, and we have settled regulations, which have settled every question with the Halifax Corporation, and all our effluent matters are settled between us. We have our Act and we have our Regulations, and we know exactly where we are.

29104. And there is no trouble?—No trouble at all.

29105. That is very satisfactory. As regards (*d*) you think that in case of accidents—I presume that is the meaning of (*d*)—they may be allowed to dispense with the standard for a certain time. For instance, if you are making alterations in your works, or introducing some new process. Is that the idea?—Yes, also if I am producing an effluent of which the standard is practically impossible, and I am able to demonstrate that. It is only a very exceptional case that could happen.

29106. The word "entitled" appears to be strong; that is all. "Should be entitled to obtain an Order"?—Which is that?

29107–8. "Manufacturers should be entitled to obtain an Order from the Central Authority to vary or dispense with a standard for good cause shown at any time." I suppose that is all right; it is a question of wording?—He would make an application, not to make an Order of course, but apply for an Order.

29109. Entitled to make an application?—Entitled to make an application; entitled to apply for an Order would be the proper phrase. They are entitled to apply.

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29110. (*Colonel Harding.*) On the question of standards, do you think that the condition of the stream ought not to be taken into account at all in fixing it?—Well, what I think is first that the stream must necessarily be subject to the riparian rights. If the stream is not a strongly foul stream, the riparian rights will keep it pure.

29111. Let me put it to you in this way rather?—I was going another step. Subject to that reservation, then I think that the trader could use the best practicable means that are known for the purpose of purifying his effluent. Subject to those qualifications, it seems to me the stream must be subservient to the trade. Directly better means are known I think the Local Government Board or the Central Authority to be appointed should be empowered to heighten the standard for that particular trade.

29112. I am afraid your answer does not elucidate what you have given us in writing; at least not to me. Do I gather from what you have told us that you mean that the standard should be what is the best practicable means, irrespective of the stream into which the effluent goes?—Yes, the best practicable means of dealing with the effluent produced by that class of trade.

29113. Irrespective of whether the stream is a pure stream or a foul stream?—Yes.

29114. So that in your idea the stream ought not to be taken into account in forming a standard?—No, not if you maintain the riparian rights. What I mean to suggest to this Commission is this, that the riparian owners are sufficiently strong, and in fact do prevent the pollution, or further pollution, of a stream that is anywhere near an ordinary degree of purity. If anybody attempted or does attempt to put polluting matter into that stream, an injunction is obtained by one or other of the riparian owners directly almost.

29115. Let me put this case. Here is a trader on the head of a stream. The waters reach him in a pure condition. Would you ask him to do the same as a trader lower down where the stream is already considerably foul?—I think so.

29116. Exactly the same?—I think so for this reason, that above you, or before you, or before the general health condition, comes the riparian owner. It would be impracticable for that man at the head of the stream to introduce an industry to pollute that stream to the prejudice of the riparian owners below. They would immediately proceed, every one of them, or one or the other of them, for an injunction against him for polluting the stream. They have a right to have the stream absolutely pure.

29117. How is it that these streams have reached the shocking condition that they have?—Well, I think you will find that those are main streams. Of course, that is a different matter. I am thinking when you say "at the head of the stream," it is a very small pure stream.

29118. You say the riparian owner is quite able to look after himself?—Quite.

29119. How is it in fact that he has not looked after himself?—Well, I think with regard to most of these small streams that the heads of the streams are fairly pure in our district.

29120. Obviously they are pure before they reach the manufacturer?—Yes.

29121. But would you deal with the first manufacturer in precisely the same way as with the last?—I think so; it seems to me they must be all on an equal scale.

29122. Then surely the standard must be a somewhat high one?—Well, I think not. I think that the standard must be gauged by the trade. I think anything above that standard will be fixed and regulated by the riparian owner. A riparian owner may be a public authority, or he may be a private owner, but according to my experience the riparian owners are very jealous indeed of any interference with the quality or quantity of the water.

29123. But notwithstanding the riparian owner, many streams in Lancashire and Yorkshire have become extremely foul, have they not?—I am bound to say that is a fact, but I go further, and I am bound to say that

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if every riparian owner had exercised his right from the commencement, there could not have been pollution now. But I think the riparian owners are sufficiently wide awake at the present time to prevent further pollution of the pure sources of the streams.

29124. What would you do in dealing with a man who proposed to start a new works on a stream, works which are likely to produce unsatisfactory effluents? Would you suggest that the local authority or the Rivers Board, if there is one, should give notice to such person that he would be called upon to carry out certain purification works if he started his works?—I do not think it would do any good, and I do not think it would do any harm, because when any manufacturer or any person is about to start any works on a stream, one of the first things he considers is how he is going to deal with his effluent. It is a matter of common property amongst traders, the question of effluent. And he would also consider the next thing, if the stream that he was going to commence his industry upon was a pure stream, the very first thing he would consider would be the riparian owners below him; and the first consideration that would impress itself upon his mind would be that he could not possibly put anything into that stream which would pollute it as against those owners, for he would be blocked at once. In practice that would be so. If the stream, on the other hand, was an impure stream, such as the Calder or the Hebble, or the other streams which are polluted now, then he would consider before what is the standard which this class of trade has to conform to, and if he put down works to conform to that standard it seems to me that is all he ought reasonably to be asked to do.

29125. I am exceedingly pleased to hear you say, Mr. Marshall, that a manufacturer proposing to start works would, in the first instance, consider how he was going to deal with his effluent?—I think so.

29126. I am afraid in practice it is not the first and important subject to which he gives his attention?—Then I think that gentleman should suffer for it afterwards.

29127. Quite so. Then you see no objection at all to one or other of those authorities giving notice to a person proposing to start a business that he would be expected to carry out certain works?—I think there is no objection; there may be no objection to that, provided there is a standard which is applicable to other works in the same class of business.

29128. Therefore a person starting work of that kind would be bound to provide for carrying out those works? —I think so, or he would have to take the consequences, the same as other people. I think that is only reasonable.

29129. I was afraid from one of your answers, criticising the evidence of previous witnesses, that you thought differently?—No, what I say is, there was put in a suggestion that there were to be further heavy penalties on a new manufacturer if he did not provide works. What occurs to me is that if he has notice he would have no excuse afterwards for being called upon to suffer in the same way as other manufacturers who are already there. I do not think he ought to be put in a different position from another trader.

29130. Then passing away from that point of the new trader to this of the existing traders, do you think it would be an advantage to have a common standard applicable to them all for their particular trade?—I think it would be; that is in practice most satisfactory.

29131. Then in that case it would appear to be necessary that the standard should be somewhat high, with lattitude to the administrative body to relax it in cases where they found it desirable to do so?—Well, that would be a question for consideration in fixing it, whether the standard might be a high one or a low one. It is a question of detail. I think in principle there is not much between us.

29132. I would like to know exactly what you mean by saying that you think the stream should be subservient to the industries of the district?—What I mean is this; that if a man does his best according to known means to comply with his standard, he cannot do better, because the water in his stream is purer than the water of another stream upon which another manufacturer is. What I say is, that directly you fix your standard I assume that is a standard applicable to that trade, and it is the duty of the trader to carry out that standard by the best practicable means. I think that is the basis upon which we think a standard is practicable. If he does his best he cannot make it more practicable because of the quality of the stream.

29133. You told us just now you thought the stream ought not to be taken into consideration?—Subject to the reservations I gave.

29134. That there should be a standard which should be a reasonable and practicable standard, and that the stream should not be taken into consideration?—With the reservations I gave.

29135. What do you quite mean by saying that the stream should be subservient to the needs of the district? —Subject to the reservations I stated, viz., the exercise of the riparian rights, and the best practicable means to comply with the standard being adopted.

29136. I rather thought you meant this, that the district ought not to claim to have a pure stream passing through it, because there were advantages to the district itself in the presence of manufactories; that these people are large ratepayers, and that therefore the condition of the stream ought to be winked at?—Well, if you are in a district, and you find the riparian rights do not keep that stream clear, it is of such importance to the manufacturers that it is to the interest of the district that, provided the best practicable means are used, the trade should continue, and to that extent the streams should be subservient to the trade.

29137. You think it is of greater importance to the district that these manufactories should be there than that the stream should be clean?—Certainly, subject to the reservations I always provide.

29138. That may be so in regard to that district, but what about the districts below who are not interested in this trade, and do not receive any payment of rates from the people who foul the stream?—Well, then again at the foot of this stream they must to a certain extent take the stream as they find it with the need of the localities above them.

29139. I am afraid I do not quite understand what you mean there. They are to take the stream as they find it, but the stream was not always so within the memory of man; the stream was different. My only object in pressing this point, Mr. Marshall, is that I would like you to understand what I was trying to get at. You do not think that the foul condition of the streams ought to be a sufficient excuse for making no effort to purify them?—No, and I think you go rather further than I do in this. You take your stream below; you say: "But what about the rights of the people below." They have their riparian rights precisely the same as above, and directly that polluting matter reaches them they can apply for an injunction to stop it.

29140. In fact they have not done so, you say?—Then if it is not of sufficient importance to the district below to exercise their riparian rights to get it, then I think again the stream should be subservient. The rights which the riparian owners have are so strong on that stream from the source to the mouth, that it seems to me, subject to the preservation of those riparian rights and the best means being used by the trader, the stream should be subservient to the trade, because in any one of the cases which you suggest, the riparian rights are sufficiently strong to prevent it at the moment.

29141. We find in fact the riparian rights have not been sufficiently strong to prevent any fouling of these streams. I merely wanted to find out whether the foul condition of the stream ought to justify pollution, and I think you do recognise, although the districts immediately surrounding the manufactory in question may be benefited by the presence of the manufactory, the districts below are not so benefited, and have a right to receive waters which are not so polluted?—That right they can enforce by the exercise of their riparian rights.

29142. Well, they might have done. It is difficult for them to do it now.—They can prevent it getting worse.

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29143. Do you recognise as representing a large body of manufacturers the necessity which rests upon those manufacturers to do everything possible to prevent the pollution of the stream ?—Absolutely.

29144. I am very glad to hear you say so, because your answer about subserviency of the stream to the district rather led me to infer that you took another view.—No, and I think my explanation of the reservations that I mean has cleared that.

29145. Now you say further on that you think local authorities should be compelled to receive trade effluents. —What page is that ?

29146. It is in answer to Question 5. You say the sewers of a sanitary authority should not be deemed to be sufficient for the requirements of their district unless the sewers are sufficient to receive and dispose of the trade effluents within the area.—Yes.

29147. Do the local authorities agree with your view in your district ?—They do in our district, because of course they receive them. In Halifax they do receive them.

29148. Do they not at Shipley ?—Outside; I think there are some of the outside districts where they do not. Well, there must be several outside districts where the sewer system is not sufficient at present to receive trade effluents, and do not receive them.

29149. The view you express of course is one very commonly held that it is on the whole the best plan for the authority to receive trade effluents, and deal with them *en bloc.*—Yes.

29150. But evidently they cannot always do so. There must be exceptional cases where it is not practicable for the authority to do it ?—That is a question I should leave to the Central Authority; it would be an exceptional case.

29151. That is the sort of dispute between a local authority and a manufacturer which might properly be settled by a Central Authority ?—Yes, *prima facie,* I think the sewers should be sufficiently large to take trade effluent. In a special case, I think that would be a proper case to be settled by the Local Government Board.

29152. No hard and fast line can be laid down ?—Oh, no. It might be an exceptional case.

29153. In the Halifax case to which you refer certain preliminary treatments had been laid down for the trade effluents, and I think certain payments were carried out.—Yes.

29154. And that you suggest is a proper course to follow in any case ?—Yes. We have a right either to go in, subject to preliminary treatment, and if we do not preliminarily treat we must make payment.

29155. You must make money compensation ?—We must make payment and we have agreed the payment.

29156. Such preliminary treatment is mainly in the direction of solid matter, suspended matter ?—Yes, mainly, there is no qualification or no definition of preliminary treatment in the Halifax Act, "where there shall be no preliminary treatment."

29157. If a manufacturer is called upon to expend any money in preliminary treatment, or pay a sum in compensation for failing to do so to the local authority, you express the opinion that the expense to which he goes should be allowed in the assessment of the net annual value of the trade premises.—Yes.

29158. Do you really think that is a fair thing ?—I do, because I look upon that as a necessity to enable his trade premises to be adapted to the trade which he is carrying on, and, therefore, it is a special outlay. It is an expense to enable those premises to be properly so adapted; and that is so in Halifax. The clause is in the Halifax Act, and it was followed in the Huddersfield Act, and it was followed in the Heckmondwike Act. It is in all three of those Acts. Now, the clause is: "In the assessment of the annual value of trade premises for rating purposes any expenditure under this part of this Act required to be incurred by the trader to enable such trade premises to fulfil the requirements of any regulations for the time being in force with respect to such premises shall be deemed to be included in the words 'other expenses' in the interpretation of the words 'net annual value.'"

29159. What about the removal of ashes ? A great many people who do not turn out effluent at all have steam engines, and therefore, produce ashes, which have to be removed by carts. Ought they also to deduct the cost of such removal from their net assessment ?—No, I think not.

29160. Why not ?—No, I think not. I think that is quite a different thing from trade effluent.

29161. It is simply a solid refuse instead of a liquid one.—A solid refuse instead of a liquid one; I agree.

29162. Well, is it not so ?—Well, no; I think the trade effluent requires a man specially to adapt those premises to the requirements of the district, but the removal of ashes is common to everybody; common to all trades.

29163. Well, there are a great many trades, quite apart from ashes, that produce solid trade refuse, and if you are to allow the deduction on the cost of dealing with liquid refuse you must allow the cost of dealing with solid refuse ?—I think that might come under another section of this Act, I think that might come under Sec. 10. There the sludge that is produced by this; the trader here has a right to call upon the Corporation, who may remove the sludge at his cost, so that would be more on the basis of your ashes; we have to pay for the removal when it comes to removal.

29164. It is not a very important point, but it seemed to me that if you were to allow a deduction on the cost of dealing with liquid refuse you must allow also a deduction in cases of dealing with solid refuse, and that is not done, or called for in the case of liquid refuse. Passing to another point, I notice in the last page of your evidence you refer to the question of taking samples in works ?—Yes.

29165. You would recognise, of course, the necessity of the supervising authority being able to take samples ?—I think so.

29166. There are many difficult cases; where the effluent passes underground into a covered bed or stream or culvert it is exceedingly difficult for a Rivers Board to get samples ?—Yes.

29167. And where indeed effluents may be flowing from several different manufactories into a covered bed ? Yes.

29168. Do you see any objection to a manufacturer being called upon in such a case to provide a man hole which would be readily accessible for the taking of samples? —I will tell you what I did, how I met that point in Halifax in the Halifax Act on the question of the Regulations. We agreed upon these Regulations. "2 (*a*) The Corporation may construct and maintain at their cost at or near the outlet of the drain into the sewer, an examination shaft and apparatus so designed as to enable the Corporation, or their officers, to obtain from time to time samples of the trade refuse discharged into the sewer."

29169. That is something similar ?—Yes. "2 (*b*) Any sample obtained by the Corporation for the purposes of this Act shall be taken in two bottles of similar size and construction, and shall forthwith, before removal from the premises, be securely sealed up and signed and marked with the date and time of and place where taken by the person taking the same, and one bottle shall be left by such person with the trader, or his representative for the time being in charge of the trade premises affected." Subject to that we were all agreeable that they should have every facility.

29170. Then you agree that the manufacturer should be called upon to make his effluent accessible to the supervising authority ?—Oh, I think so; I think that is the general opinion.

29171. But, as a fact, you know that in a great many cases it is not so accessible ?—Yes, I believe there are cases where if people stood on their rights they might possibly make it inconvenient to take a sample or to go. Personally, I have not known very much difficulty.

29172. You do not see any harm in a manufacturer being called upon to provide an accessible manhole so as to allow samples to be taken ?—I do not see any.

Mr. Walter Leach, F.C.S., and Mr. Harold Marshall.

15 June, 1909.

The only difference between that and this is that in Halifax we do it at the cost of the authority. I should go further on the question of samples and say this, that in my experience manufacturers or traders, or whatever you like to call them, have not put any difficulties in the way of samples being taken; they do not in practice put any difficulty in the way of samples being obtained at any time. But what they think is this, they feel an objection to secret samples. What I mean by that is, if any authority come to them and say: "We want a sample of your effluent," they will say: "Go and take it; you can have every facility." But they do object to secret samples. They object to being treated as being under a suspicion. That is my experience of traders as a rule. Possibly I ought to say that I noticed in Mr. Atter's evidence one case where the manufacturer had ordered the representative of the Rivers Board off the premises. That was stated in his evidence, and that was in Halifax, on the Ovenden Brook. I should like to state that as a matter of fact that did happen, but it happened under a misapprehension. The man happens to be a client of mine. Afterwards he came to me, and directly he told me—this was only eighteen months ago—I said: "You ought not to have done it; you should give him every facility possible," and he assures me that he did from that time, and from that time there has never been any objection at all. It was quite a misapprehension at the time.

29173. (*Chairman.*) Thank you very much for coming before us and giving us your valuable evidence.

Statement sent in subsequently by Mr. Walter Leach.

TEST OF THE SMITH-LEACH PROCESS FOR TREATING WOOLCOMBERS SUDS AT FIELDHEAD MILLS, BRADFORD. TREATING EFFLUENT FROM PURE AUSTRALIAN GREASY WOOL ONLY.

Quantity of suds treated per week, 55,000 gallons.

Actual running time of Yaryan Evaporator, forty-six hours.

	£	s.	d.	£	s.	d.
2 tons of pure wool fat, at £15 per ton	30	0	0			
1 ton of carbonate of potash at £15 per ton	15	0	0			
44,250 gallons distilled water, at 6d. per 1,000	1	2	0			
Actual soap saved by using above water	2	2	0	48	4	0
Coal used	10	1	3			
Wages paid	3	8	3			
Interest and depreciation	12	0	0	25	9	6
Balance				22	14	6

CAPABILITIES OF THE PLANT.

Quantity of suds, 110,000 gallons per week.

Actual running time of Yaryan Evaporator, ninety-two hours.

	£	s.	d.	£	s.	d.
4 tons of pure wool fat, at £15 per ton	60	0	0			
2 tons of carbonate of potash, at £15 per ton	30	0	0			
88,500 gallons of pure distilled water, at 6d.	2	4	0			
Actual soap saved by using the above water	4	4	0	96	8	0
Coal used	15	0	0			
Wages paid	5	8	0			
Interest and depreciation	15	0	0	35	8	0
Balance				61	0	0

NOTE.—All grease sold up to to-day has been at £20 per ton. If the plant was running continuously night and day the profits would be proportionately larger.

Mr. ROBERT CLAY, Cheadle; and Mr. WILLIAM MARSHALL, called in; and Examined.

Mr. Robert Clay, and Mr. William Marshall.

15 June, 1909.

29174. (*Chairman.*) We are much obliged to you for coming to give us the benefit of your evidence?—(*Mr. Clay.*) Thank you, Sir William; I do not know that I can say much to assist you.

29175. We propose to print *in extenso* the whole of the statement which you have kindly furnished.—If you please.

The Micker Brook from which I derive my water supply rises some 8 or 10 miles away and is both a narrow and a shallow stream. There are two sewage works, Poynton and Bramall, above my works, the effluents from which enter the brook necessarily with other local pollutions affecting the quality of the water.

The sides of the brook are of a loose clayey character, and after rainfall a large amount of suspended matter is brought down.

I have, therefore, been compelled to filter the water previous to using and a great quantity of this suspended matter is deposited in the bed of the reservoirs and filters, soon clogging up the latter, which require constant renewal.

A portion of the clayey matter cannot be removed by filtration, and passing through the various processes in the works finds its way through the effluent into the brook.

Cost of tanks, filters, etc., for 1,000,000 gallons per day, exclusive of land, £7,500.

Interest on capital, depreciation, steam, filtering materials and wages, £1,007 10s. per year.

Three filters, 62 feet by 27 feet 6 inches by 7 feet, holding 42,000 gallons each.

Receiver, 74 feet by 36 feet by 12 feet, holding 150,000 gallons each.

Large tank, 247 feet by 75 feet by 10 feet 6 inches, holding 1,000,000 gallons.

PURIFICATION OF WASTE WATER.

The whole of the water used in my processes passes to the first series of three settling tanks for treatment, and here a large amount of sludge is deposited.

It is then pumped from the last tank of the series to the seven higher tanks. The first three are worked on the continuous method, the water afterwards passing into, the remaining four, where it is allowed to stand as long as possible.

The tank effluent is then passed through filters into the stream.

The sludge is pressed and carted away.

The total cost, exclusive of land, for this portion of the plant is £10,250. It comprises engine, tanks, various machines, fittings, and buildings.

Interest on capital, depreciation, steam, chemicals, disposal of sludge and wages, £2,375 per year.

Volume of waste water treated, about 1,000,000 gallons daily.

Capacity of tanks:—

Three in first series, 53 feet by 30 feet by 5 feet, holding 48,000 gallons each.

One in first series, 37 feet by 28 feet by 4 feet, holding 25,000 gallons.

Seven in second series, 56 feet by 36 feet by 8 feet, holding 90,000 gallons each.

Three filters 36 feet by 30 feet by 3 feet 6 inches, holding 20,000 gallons each.

These are sunk 10 feet below ground level.

Sludge receiver 35 feet by 30 feet by 6 feet, holding 32,600 gallons.

With regard to the questions raised in Clauses 1, 2, 3, 4 and 5 in your letter to me:—

I think it has been generally recognised that the requirements of the law shall not be of such a stringent nature as would have the effect of crippling the respective trades of the country and that a manufacturer should only be required to use such reasonable means as would not appreciably interfere with the success of his business.

It certainly would be desirable to fix a standard for the various trades so that competitors would work under similar conditions.

At present this is not so, as in some places little or nothing has been done.

The character of the stream, the nature of the business, and the position of the works should be taken into account in all cases.

I can only speak of my own method of purification, and in doing so point out that such method occasions much supervision, and under the circumstances of very keen competition is not within reasonable limits of cost.

There are certainly many cases where trouble is experienced in satisfactorily purifying effluents, as in my own case, certain colours are only removed with difficulty.

Speaking of the watershed in which my works are situated, I do not see that it would be any advantage to alter the law further than each manufacturer being required to adopt every reasonable means of purification both before and after using the water.

As some disputes might arise in the working of so elastic a measure, would it not be advisable for a Government Department to be formed so that it might be appealed to previous to any legal proceedings being taken by any authority in question ?

29176. (*Mr. Tatton.*) There are just a few things I want to ask you. I see you divide up your evidence into the cases of treating the water, in the first instance, and then the cost of treating your trade waste ?—Yes.

29177. On the first page you estimate your cost to be about £1,000 a year. That is simply for the filtration of the water supplying your works ?—For the filtration, yes.

29178. Can you tell us at all what the cost of the treatment of your effluent by itself is ?—Yes, I think I have stated the cost.

29179. Oh yes, I beg your pardon, the interest on capital, depreciation, steam, chemicals, disposal of sludge and wages, £2,375 a year ?—Yes.

29180. That is what it costs you ?—Yes, for the treatment of effluent.

29181. Then the result is uniformly satisfactory, is it not, as far as the Rivers Board is concerned ?—I believe it is fairly satisfactory to the Rivers Board but not to the individual.

29182. The Rivers Board will be able to deal with that ?—Yes.

29183–7. Now as regards standard, you rather lean towards the best practicable reasonable available means ?—Yes, I find the difficulty in the question of standards to be, how you can make one. I do not know what authority has a standard at the present time, a fixed standard. For instance, a standard on my stream would be and ought to be quite different to a standard on a stream from which several dyers take their supply and into which they turn their effluent.

29188–9. Would it be more difficult for that manufacturer to purify his trade waste than it is for you ?—Well, I think so. Do you not think so, Mr. Marshall ? (*Mr. Marshall.*) Yes. I am sure it would be more difficult for him to get out the whole of the previous pollutions there might have been in the water than it would be if he were using a simple clear water. (*Mr. Clay.*) On my stream I am practically a first user, with the exception of sewage works above me, and the natural pollution from a country district, drainage from cowsheds and cottages flowing into the stream. I am the first user, so that I naturally have a clearer water, with all those drawbacks, than a dyer would have on such a stream as I have mentioned.

29190. Then would you suggest that a standard should vary according to the conditions of the stream into which your effluent was discharged ?—Yes, when the water supply comes from the stream. I do not see how it could be otherwise. You have so many things to take into consideration, the nature of a man's business, the water as it comes to him, his position upon the stream, and whether he is adodting the best means of purifying his effluent. But, of course, in the fairness of trade one manfacturer ought to be bound to purify and give as good an effluent as another, because the man to whom you give a little license that his effluent should not be quite up to a fixed standard competes with the man whom you require to do it very well, and to that extent the latter is penalised in his business. For instance, in my own case it is not a trade where goods are of the value, for the dyeing, of £1 each. Whatever work I put upon them, they would not be more than 6 shillings each for the dyeing, and they will run down to probably half-a-crown. Therefore, with the extreme competition I have to meet from competitors who have not put down any purification plant at all, or plant of very limited extent, as the Irish Dyers, the Scotch Dyers, and the Yorkshire Dyers, I consider that it comes heavily upon me having expended all this money.

29191. You think that is unfair ?—I think that it is manifestly unfair. I do not say for a moment that I have done more than I ought, but I say my competitors should be called upon to do as much.

29192. Then it would not be unfair to make the man on the Irwell put down works as good as yours ?—No. He meets me in competition, and should be required to give as good an effluent as is expected from me.

29192*. You say he might not be able to get the effluent quite as good ?—Not quite, your difficulty would be probably want of room—land.

29193. That is not the case with you, of course ?—No.

29194. He might or might not ?—He might or he might not, probably the greater supposition would be that he would not.

29195. But if he had room you would make him do it ?—Yes.

29196. You speak of certain colours being only removed with difficulty ?—Yes.

29197. Could you tell what those are ?—(*Mr. Marshall.*) We have two basic colours, Rhodamines, which are very difficult to remove. Then we have acid colours which are termed acid scarlets, and in direct colours we have a direct black, and a yellow. These colours are not precipitated by ferric and lime, or are feebly so, therefore we get traces of them in the effluent, and at times we cannot possibly remove the traces.

29198. (*Chairman.*) But they do no real harm, I suppose ?—They do no real harm.

29199. They merely discolour the water ?—They do no real harm in the stream at all.

29200. Even to dyers situated below you on the stream ?—No, there is not sufficient. When we have a fair amount of bleach liquor coming through, the bleach liquor will remove those traces and then we get a perfectly clear effluent, but if we are using a large quantity of that particular colour we have a difficulty in getting the last traces out.

29201. (*Mr. Tatton.*) Do those dyes affect the treatment apart from the colouring, I mean to say, do they make it more difficult for you to treat your trade wastes when you have those dyes coming down ?—No.

29202. It is simply a matter of colour ?—Yes. I have samples of the colours here, if you would like to see them.

29203. (*Secretary.*) We can see those afterwards, perhaps ?—Yes.

29204–6. (*Mr. Tatton.*) Do you think that a Government Department would help you ? If a Government Department were instituted would you like that proposal ?—(*Mr. Clay.*) I do not see how you will administer an Act without it. In the interests of the various Rivers Boards and the manufacturers too, I think there should be some authority over both, an authority to which either could appeal, and, in the case of an intended prosecution, the authority should say whether such prosecution should take place or not. I do not quite like the idea of its being subject to the decision of any Local Authority quite independently of a Supreme Authority.

29207. You have a bleach works below you ?—Yes.

Mr. Robert Clay and Mr. William Marshall.

15 June, 1909.

29208. (*Colonel Harding.*) Your case, Mr. Clay, is really interesting to us because you have spent these large sums in loyally trying to do your duty ?—Thank you, Colonel.

29209. We had the pleasure of visiting your works, and we noticed the public spirit with which you carried out your responsibilities ?—Thank you, Colonel.

29210. And we are happy to think that it has not really crippled your industry to do this ?—It has not absolutely ruined me, but it has crippled the industry.

29211. Well, that is, of course, a very interesting point for us, and we appreciate that in your case you had the advantage of having plenty of land available for the purpose ?—Yes.

29212. That in other cases a manufacturer might have to purchase land at very serious cost from an adjoining owner ?—Yes.

29213. Therefore you are quite right in saying that the circumstances of all manufacturers are not identical ? They are not identical, only unfortunately those people that you let off with very little expenditure compete with me and pull down my prices.

29214. That is rather the point that I wanted to ask you a question about. You say that you feel the industry is crippled under the circumstances of the keen competition with people who are not called upon to do anything or not to do so much ?—Yes.

29215. But you do not suggest, do you, that a bleacher, for instance, wherever he is and whatever the circumstances of the stream on which he is placed, should be called upon to do exactly the same as another ?—If he is upon the same stream.

29216. Take, for instance, you mentioned a certain Irish competitor, well I do not know where they are ?—They are principally about Belfast.

29217. Belfast. Well they might be on a tidal stream where it might not be necessary to carry out works to the extent that you have carried them out ?—No.

29218. The volume of the stream into which they turn their effluent might relatively be very large ?—Yes.

29219. Well, would it not be rather a hardship if you were to call upon a manufacturer in those circumstances to do exactly the same thing as you would call upon a manufacturer to carry out in the case of a stream of very small volume ?—No, Colonel ; the hardship comes upon the man with the small stream, I think, does it not, not the man on the large stream. I wish mine were a large stream.

29220. You cannot make the conditions of competition equal ?—You cannot ; that is the difficulty I feel.

29221. Suppose you did with regard to trade effluents, there are many other things, for instance, you are carrying on your works under conditions of having the very interesting City of Manchester close to you, which probably makes the amenities of life very pleasant ?—Probably.

29222. While another person is on some desolate bank of a stream in Ireland, and he might consider that there were corresponding disadvantages in his case. It is quite apparent that you cannot equalise the conditions of competition can you ?—You cannot equalise them at all.

29223. But he may have to pay much more for coal ; he may be a long way from collieries, and so on ?—Yes.

29224. I was only questioning whether what you claimed was really practicable: that all manufacturers in the same business in Great Britain and Ireland should be called upon to carry out purification works to the same extent ?—I cannot see how you can do it, but the justice of the case would demand it in competition.

29225. I think not, because, no doubt, there would be other compensating advantages ?—But who shall judge ?

29226. One may be nearer to coal than another ; you cannot equalise the conditions of competition ?—No.

29227. (*Chairman.*) Surely if you are to demand a certain standard for your effluent you would, in practice, reach those conditions ?—Yes.

29228. If you were to demand a certain standard of effluent in a certain trade, every one would have to conform to that standard.

29229–30. (*Colonel Harding.*) If the standard were to be enforced, irrespective of the stream into which the effluent goes ?

29231. We do not know, of course, what the circumstances of these Irish dyers may be, but it may be that the local authorities in that neighbourhood may become alive to the necessity of getting them to do something.

29232. (*Chairman.*) If you had an uniform standard insisted upon, that difficulty, so far as that particular question of purifying effluents should go——

29233. (*Colonel Harding.*) And that is Mr. Clay's point ?

29234. (*Chairman.*) That is Mr. Clay's point.

29235. (*Colonel Harding.*) But that is that there should be a uniform standard ?

29236. (*Chairman.*) That is that there should be a uniform standard ?—If it could possibly be done. Although I see the difficulty of doing it, still, in fairness, it ought to be so.

29237. (*Colonel Harding.*) In your written evidence, Mr. Clay, you say this: "The character of the stream the nature of the business, and the position of the works should be taken into account in all cases ?—Yes, I cannot see how you can do it in any other way.

29238. You agree that the character of the stream and the position of the works upon it must be taken into account ?—Must be because in some cases it would mean absolute ruin to a man. Oh, yes, I quite admit that although the hardship is still there that you, in competition, have to bear the expenses, and your competitor practically nothing. Of course that is a matter of situation for the works, is it not ? As to the question of sewers and the local authorities taking the effluent into the sewers, I do not agree with that at all. I think that is giving one manufacturer a decided advantage over another in the matter of the sewers taking the effluent.

29239. (*Chairman.*) If the one has access and the other has not ?—Yes, quite so. In my own case it would pay me for the Cheadle Authority to treat my effluent. I should be in pocket. So that the man who could get into the sewers would obtain a considerable advantage over a competitor who must turn his effluent into the stream.

29240. Is it impossible for you to get into the sewers because you are obliged to return the water that you take from the stream ?—Yes ; and how the authorities dealing with waste water could replace that water in its exact position in the stream again I do not know, because the works would be some distance away, and the manufacturers down a stream would have less flow, so I do not see how the local authorities could do it very well. Anyway, I should be very glad to pay a considerable sum of money to the local authorities, if they could deal with my waste water.

29241. We are much obliged to you for coming to give your evidence ?—Thank you, Sir William.

NINETY-THIRD DAY.

Wednesday, 16th June, 1909.

PRESENT.

The Right Hon. The Earl of IDDESLEIGH (*in the Chair*).
Colonel T. W. HARDING, J.P., D.L.
Sir WILLIAM RAMSAY, K.C.B., F.R.S.
Sir WILLIAM H. POWER, K.C.B., F.R.S.
Mr. T. J. STAFFORD, C.B., F.R.C.S.I.
Mr. R. A. TATTON, M.Inst. C.E.
Mr. F. J. WILLIS (*Secretary*).

ALSO PRESENT.

Dr. GEORGE MCGOWAN.
Mr. G. B. KERSHAW.
Mr. C. C. FRYE.

Mr. JOHN H. HANSON, of the firm of Abbey and Hanson, Engineers to the West Riding of Yorkshire Mill-Owners' and Occupiers' Association; Mr. ALFRED SYKES, J.P., President of the Association; Mr. CHARLES MILLS, of Huddersfield, Solicitor to the Association; and Mr. THORP WHITAKER, of the Bradford Dyers' Association, called in; and Examined.

29242. (*Chairman.*) I propose if there is no objection to put these statements on to the evidence just as they stand?—(*Mr. Mills.*) That is so, my Lord.

THE WEST RIDING OF YORKSHIRE MILL-OWNERS' AND OCCUPIERS' ASSOCIATION.

STATEMENT BY JOHN H. HANSON, OF THE FIRM OF ABBEY & HANSON, ENGINEERS TO THE ABOVE ASSOCIATION.

The above Association was formed in June, 1897, and was an extension of a previous Association called the "Colne Valley Water Mill-Owners' Association" which had existed since 1874 for the purpose of protecting the water rights of the mill-owners on the River Colne.

The Colne Valley Water Mill-Owners' Association employed a river inspector for the purpose of preventing the deposit of solids in the bed of the river, and any diversion or interference with the free flow of the water.

The Association entered upon many prosecutions to protect their water rights.

Amongst other proceedings, this Association obtained an injunction against the Huddersfield Corporation for depositing snow from the streets of the town, in the bed of the river, containing a large quantity of road materials and other solid matter.

In the year 1894, when the West Riding of Yorkshire Rivers Board had been formed, the Association decided not to continue the services of an inspector, and, together with other mill-owners on the River Holme in the West Riding of Yorkshire, formed a separate Association which ultimately was extended and became known as "The West Riding of Yorkshire Mill-Owners' and Occupiers' Association." Its area includes practically the whole of the districts in which the woollen and worsted industries are carried on in the West Riding of Yorkshire, and its objects are as follow:—

> "To watch over, protect, and promote the interests of the members whose works are affected by the Rivers' Pollution Act, 1876, the West Riding of Yorkshire Rivers' Act, 1894, and other Acts relating to the fouling of rivers by trade refuse, and to obtain information generally on the subject both as regards liability and the best means of dealing with the question."

The firms included in this Organisation number 241.

An Executive Committee was appointed, who have visited many parts of the country from time to time, where information could be obtained as to the best means for dealing with trade refuse, and this information has been distributed amongst the members of the Association.

Eighty-seven members of the Association have put down works either for partially or wholly treating their trade refuse, and it is from some of these plants that chemical evidence is now being obtained, the result of which will be placed before the Commission at their October meeting.

In 1898, on account of the difficulties which the Executive Committee met with owing to the want of scientific information as to the best means of dealing with trade refuse, and there being no authority having such special knowledge to whom they could apply, and under the pressure of numerous proceedings against the members of the Association by the West Riding of Yorkshire Rivers Board, the Committee made the following offer to the West Riding of Yorkshire Rivers Board with a view of obtaining knowledge by experiment which would be valuable to the whole of its members.

Mr. John H. Hanson, Mr. Alfred Sykes, J.P., Mr. Charles Mills. and Mr. Thorp Whitaker.

16 June, 1909.

[COPY.]

20, Ramsden Street, Huddersfield,
June 15th, 1898. J.H.H.

Trevor Edwards, Esq.,
West Riding Rivers Board,
Wakefield.

DEAR SIR,—The Committee of the above Association are desirous and willing to put down an experimental plant for the purpose of dealing with the trade waters of some one of the members of the Association, in order to gain experience for the whole of the members of the Association, but having regard to the feeling that the works which have been pointed out to them, and which they have seen hitherto, have been, in their opinion, so very unsatisfactory, they would be glad if the Rivers Board would point out to them some particular plant, which, in their experience, has so far met the requirements of the Rivers Board.

Of course it should be a plant which has been put down within reasonable limits as to cost, so as not to be prohibitive on that ground, and should be more especially adapted to trade waters arising from the dyeing and scouring of woollen goods.

We shall be glad if you can assist us in this matter, after which the Committee would decide as to where the plant should be fixed so as to give it such a test as would be generally useful to the manufacturers in the Colne and Holme Valleys.

Yours faithfully,
(*Signed*) ABBEY & HANSON.

[COPY.]

West Riding of Yorkshire Rivers Board,
Wakefield,
June 27th, 1898.

DEAR SIRS,—Mr. Edwards has handed me your letters of the 15th and 24th instant. I have to remind you that at your interview with Mr. Edwards and myself on 7th October last, various places were pointed out

Mr. John H. Hanson, Mr. Alfred Sykes, J.P., Mr. Charles Mills, and Mr. Thorp Whitaker.

16 June, 1909.

where Purification Works had been constructed by manufacturers, which were capable in my opinion of giving satisfactory results.

At the following mills efficient methods for the purification of such waste liquids as you have in the Colne and Holme Valleys can be seen:—

Bentfield Mills, Greenfield, Messrs. S. Heap & Son, where piece scouring and milling water is treated very satisfactorily.

Slackcote Mill, Delph, Robert Byrom, where wool washing, piece scouring, and dye waters are treated. At these mills, however, the filtering arrangements are not so satisfactory as they might be.

Woodhouse Mills, Norden, Near Rochdale, Messrs. Kelsall & Kemp, where piece scouring and dyewaters are treated to the satisfaction of the Mersey and Irwell Joint Committee, and at

Clay's Works, Cheadle, Cheshire, Messrs. R. Clay & Son, where the bulk of the trade waste is dyewater, and where the effluent is satisfactory to the Mersey and Irwell Joint Committee.

With these places you are no doubt already familiar, and I would point out that in all of them the principle of chemical precipitation in settling tanks with filtration of the tank effluent has been adopted, and that the question of efficiency and cost is entirely one of engineering upon which you yourself are best able to advise the Association. You will no doubt, profiting by the experience of the above manufacturers, be able to prepare for the Association plans of works which will give a satisfactory result, and at no prohibitive cost.

Faithfully yours,
(*Signed*) H. MACLEAN WILSON.

Messrs. Abbey and Hanson,
Colne and Holme Mill-Owners' and Occupiers' Association,
20, Ramsden Street, Huddersfield.

The Committee inspected the Works referred to in Dr. Wilson's letter, and have advised the adoption of some of the methods they found being used.

The Association has been the means of obtaining Acts of Parliament for Huddersfield and Heckmondwike, dealing with the question of trade refuse, and during last Session of Parliament they assisted Ravensthorpe Urban District Council in promoting a Bill which was ultimately lost in consequence of the projected extension of the boundaries of the Borough of Dewsbury so as to include Ravensthorpe, but the traders and the Urban District Council were quite agreed as to clauses with reference to trade waters.

The principle of these Acts of Parliament which provide for the admission of trade refuse into public sewers is approved by the traders, and has also been approved by the Committees of both Houses of Parliament, it is no doubt well known to the members of the Commission, and should be made to apply to all traders within reach of a public sewer.

Practically every important point of law affecting the rights of traders in the public sewers has been taken to the High Courts to get a definite judgment, defining those rights, and these judgments all tend to show the great uncertainty which existed in the various Acts of Parliament dealing with the subject, and the necessity for new legislation.

The great want which the traders have found during the last ten years has been an authority, who had themselves investigated the various methods of dealing with trade refuse, to whom they could apply for information and guidance.

The traders feel it to be desirable in the best interests of the country that a fully equipped Central Authority should be established, to which traders could apply for information, and guidance, and who should be empowered to deal with all disputes between sanitary authorities and traders. There should be no middle authority between the trader and this Central Authority on any question.

Questions 136 to end.

Upon this point, I gave evidence in the Huddersfield Bill and pointed out objections to the question being referred to the Local Government Board until this specially equipped department was established, with the result that the following Clause was included in the Bill:—

> "(13) Until Parliament otherwise provides, any question arising under this part of this Act, or under any regulations made thereunder shall if the parties so agree be referred to the Local Government Board for determination otherwise than as arbitrators, or if they do not so agree then to arbitration under the provisions of the Arbitration Act, 1889. On any reference to the Local Government Board under this section that Board may make such order in the matter, and as to the costs of the reference and of the parties as to the Board may seem equitable and the order so made shall be binding and conclusive on all parties."

And this same view is held by the traders to-day.

The Central Authority should be the authority to establish standards and to settle differences such as are set out in Pars. 56 and 57 of the Third Report.

Referring to the letter from the Secretary of the Commission, dated April 21st, 1909:—

Queries Nos. 1 and 2.

> (1) Upon what principles should the Commission proceed in framing recommendations as to the extent to which a manufacturer should be required to purify his trade effluents.
>
> (2) Should there be fixed standards for various trades, and, if so, should the law provide means by which the standard could be raised or lowered according to the character of the stream.

The members of the Association are of opinion that standards should be established for each trade, and should apply to all traders in each particular business without regard to the class of the river or stream upon which such industry may be situate.

This would get rid of unequal treatment, possible confusion, and misunderstanding, and would establish uniform liability upon all traders in the same class of trade.

Standards should not be placed too high in the first instance, with power to raise or lower the standards over terms of years, but it is desirable that this position should not arise at periods oftener than seven to ten years, otherwise it would create a feeling of unrest, which is undesirable, and also a possible wastage in plant which is and has been the experience of traders up to the present time.

With reference to the extent to which a trader should be required to purify his trade effluents before discharging them into a river or stream, we are at the present time having samples taken from different plants in various trades, and we propose to submit the analyses of these different tests to the Commission, with some approximate idea of both capital cost and annual cost of treatment to produce the result which the analyses will show.

This appears to the traders to be the best form of assistance they can give to the Commission to guide them in fixing standards, which should be such in each trade as can within reasonable limits of cost, be attained by the trader.

Query No. 3.

> (3) What methods are available for purifying trade effluents of various sorts within reasonable limits of cost, and what is the character or quality of the purified effluents produced by such methods.

I propose to deal with this part of the question in the Chemical Report to be presented to the Commission, in October next.

Query No. 4.

> Whether there are any cases in which manufacturers experience difficulty in satisfactorily purifying or disposing of trade effluents.

There has been difficulty in dealing with trade refuse containing chrome, but that has been overcome by a new process of using chrome, by which it is almost wholly deposited on the fibre on which it is used. By that method of user a very small part only of the chrome passes into the trade refuse.

(Formic acid).

In the heavy woollen industry, where chrome is used for stripping (*i.e.*, the process by which the colouring matter is removed from the woollen material) along with sulphuric acid, the new method (*i.e.*, formic acid) cannot be used, but the quantity of chrome compared with the dyewaters is comparatively small, and the presence of the chromic acid would assist in the precipitation of the dye waters.

Where size is used difficulty arose, but in certain trades a vegetable substitute for the animal size has practically disposed of the difficulty.

Fullers' earth is another difficulty, and to a large extent remains so to-day on account of the extreme fineness of some of the solids which are in suspension, which, even

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after the bulk has settled by precipitation, will still be in suspension in the effluent, and will pass through an ordinary filter, and seeing that actually this amount of solid is much less in percentage than what would blow on to a river from the highways of the country, it is more an imaginary objection than a real pollution, and should be dealt with as such in fixing standards.

The use of indigo for dyeing has caused another difficulty by reason of the presence in the effluent of minute particles of indigo in suspension, which are so fine that they will readily precipitate and pass through an ordinary filter very much in the same way as minute particles of Fullers' earth.

Indigo is a costly commodity and one which the dyers, therefore, do not unnecessarily waste.

When used in woad vats, the vat is used over and over again until the indigo is exhausted.

The contents of the vat then is very foul solid matter, and should be removed from the vat without being allowed to get into the trade effluent.

Practically the only particles of indigo which find their way into the trade effluent are those which are removed from the cloth during the process of washing or scouring after dyeing, and the percentage is small and should be dealt with as such in fixing the standards.

A Central Authority fully equipped with Scientists would investigate such difficulties as these, which will continue to arise from time to time, and be in a position to advise traders what are the means reasonably available for dealing with them. This will more especially arise in the woollen and worsted trades, where changes in processes often take place, which will create new difficulties, and it is, therefore, essential to the future success of carrying out an Act of Parliament that such a Central Authority should be established to whom both traders and sanitary authorities could submit difficulties and from whom they could obtain information, and above all, it should, by its efficiency, be an authority in whom the traders would have complete confidence.

ESTABLISHMENT OF RIVERS BOARDS.

If it is considered desirable that Rivers Boards should be established throughout the country, they should certainly act for watersheds, but the traders are not willing that questions of any description in dispute, should be submitted to Rivers Boards for decision. They should be an inspecting and prosecuting authority and should remain such, their duty being to see that standards, when fixed, are properly adhered to.

It is not desirable that it should be necessary to obtain the consent or approval of Rivers Boards to the establishment of new works.

It could only lead to friction and disputes, and if their duties are confined to pollution, pure and simple, there will be less likelihood of friction between the trader and the Rivers Board.

All Orders which have been granted for proceedings against traders should become null and void on the passing of a new Act, so that all traders shall, so far as is possible, commence a new existence under similar conditions.

The following clause, is included in the three special Acts relating to trade refuse, and should be included in any alteration of the law:—

> "In the assessment of the annual value of trade premises for rating purposes any expenditure under this part of this Act required to be incurred by the traders to enable such trade premises to fulfil the requirements of any regulations for the time being in force with respect to such premises shall be deemed to be included in the words 'other expenses' in the interpretation of the words 'net value.'"

The traders do not agree with the opinion expressed in Sec. 56 of the Third Report of the Royal Commission, that differences should be settled by the Rivers Boards.

They feel strongly that the whole of the four cases of differences or disputes mentioned in that paragraph should be referred direct to the Central Authority.

With reference to short tenancies, I do not think it is desirable that it should be made an offence for the owner of premises to let those premises for a purpose which involves the carrying on of a trade from which polluting liquids would be discharged.

This should be left to the general position of liability for pollution, and there are no tenancies for trades in the woollen and worsted industry for very short terms.

It must be borne in mind that for a trader in the woollen and worsted trade to remove his plant means a substantial cost of hundreds of pounds.

It is quite correct that a clause providing for the closing of the tenancy in the event of an Order being made against the tenant does exist in two cases that I know of, not for the purpose of avoiding liability, but for the purpose of preventing that liability being placed upon the tenant, who might be tied by a lease to his premises for a number of years, and but for this clause he would have to take upon himself the whole cost of putting down a purification plant.

A clause of this sort in a lease places a tenant in a position which enables him to negotiate with his landlord, otherwise he would be helpless.

I have read the questions and answers numbered 27366 and 27367 in Dr. Wilson's Evidence, and I disapprove entirely of the inference which Dr. Wilson's answers convey.

The traders in the West Riding have had to discover methods of dealing with their trade effluents for themselves.

The Association has been involved in very great expense in obtaining decisions of the Courts upon the many doubtful questions which have arisen as to the interpretation to be placed upon the Acts of 1876 and 1894, and have, for years, been urging upon the Local Government Board the desirability of introducing a Bill dealing with the question of trade effluents.

The Association have carried the following question to the High Court for decision.

As to whether watercourses had become sewers: *W. R. Rivers Board* v. *Reuben Gaunt & Sons, Ltd.*, *W. R. Rivers Board* v. *Abraham Preston & Sons*; *W. R. Rivers Board* v. *J. & J. Longbottom.*

As to whether a trader was liable where his effluent was discharged into a sewer: *W. R. Rivers Board* v. *Marshall, Kaye, and Marshall, Ltd.*: *W. R. Rivers Board* v. *Butterworth & Roberts.* This case went to the House of Lords.

As to whether purification works formed part of sewer within the meaning of Sec. 7 of the Act of 1876 and Sec. 10 of the Act of 1894.

Jonas Brook & Brothers, Ltd. v. *Meltham Urban District Council.* This case went to the House of Lords.

As to whether the two months' notice required to be given under Sec. 13 of the Act of 1876, could be given before the Local Government Board's consent to take proceedings has been obtained.

W. R. Rivers Board v. *Scarr End Mill Co.*

W. R. Rivers Board v. *Robinson Brothers.*

STATEMENT BY MR. ALFRED SYKES, J.P., PRESIDENT OF THE ASSOCIATION.

I am a Woollen and Worsted Manufacturer, and Director of the firm of Joseph Sykes & Co., Ltd., Rock Mills, Brockholes, near Huddersfield.

I am also connected, as Director, with other Woollen and Worsted Manufacturing Companies in the West Riding of Yorkshire.

I was elected President of the above Association in the year 1905, and have occupied that position up to the present time.

I acted on the Executive Committee prior to that date, and have taken considerable interest in the question of dealing with the purification of trade refuse, and the rivers of the West Riding.

I am also acquainted with the Third Report of this Commission, which deals with the question of trade refuse.

The following matters have been considered by the members of the Association, and I am authorised to make the following statement on behalf of the members,

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and to express their approval of the statements which have been made by the solicitor, and engineer to the Association.

The whole of the statements have been considered by the Executive Committee.

The Association has been practically the means of the Huddersfield and Heckmondwike Acts of Parliament being obtained, which deal with the question of trade refuse, and I am acquainted with the provisions of those Acts of Parliament.

The principles of those Acts as they affect trade effluents are as follows:—

Traders may discharge trade refuse into sewers.

6. (1) Subject to the provisions of this part of this Act any trader may require the Corporation to receive and dispose of the trade refuse produced from his trade premises and shall be entitled to discharge or continue to discharge such trade refuse through any drains communicating with a sewer and for such purpose shall be entitled to enlarge or alter such drains or construct new drains and cause the same to empty into a sewer subject to the provisions of Sec. 21 of the Public Health Act, 1875.

When provisions of this section to come into force.

(3) The provisions of this section shall not come into force until the expiraion of twelve months after the passing of this Act, or until the general regulations to be made as hereinafter provided shall come into operation whichever shall first happen, Provided that if the Corporation shall within nine months after the passing of this Act make and submit to the traders' representatives such general regulations in accordance with the section of this Act, the marginal note whereof is "Corporation shall make general regulations," the provisions of this section shall not come into force until such general regulations shall come into operation, Provided further that until the provisions of this section come into force the rights of the Corporation and the traders respectively as existing at the time of the passing of ths Act shall remain unaffected.

Corporation shall make general regulations

11. (1) The Corporation shall subject as hereinafter in this section mentioned make general regulations which shall be conformed to by traders who at the time of the passing of this Act discharge or shall thereafter discharge trade refuse into the sewers.

Nature of general regulations.

(2) Such general regulations shall provide for (*inter alia*) the following operations by and at the cost of the trader:—

(*a*) The exclusion from trade refuse discharged from his trade premises into any sewer of all surface and condensing water springs of water and the overflow from reservoirs of such water, Provided that nothing contained in the provisions of this sub-section shall be deemed or construed to entitle any trader or the Corporation to cause to fall or flow or knowingly to permit to fall or flow or to be carried into any river or stream any liquid which is poisonous, noxious, or polluting within the meaning of the Rivers' Pollution Prevention Act, 1876.

(*b*) The removal (where the same can be affected at a reasonable cost) from trade refuse discharged from his trade premises into any sewer of all solid matter.

(*c*) The removal from trade refuse discharged from his trade premises into any sewer of grease by preliminary treatment, such treatment to be as prescribed by the General Regulations.

(*d*) The regulation (where the same can be affected at a reasonable cost) by the trader of the volume of flow of trade refuse discharged from his trade premises into any sewer so as to ensure an uniform rate of discharge thereof into the sewers during the working hours of each working day (including overtime) for the time being obtaining at such premises.

As to payments by traders.

(3) Such general regulations shall also provide for the payment by the trader to the Corporation of reasonable charges for the reception and disposal of trade refuse where the trader is unable to effect the removal required by Sub-sec. (2) (*b*) and (*c*) or the regulation of flow required by Sub-sec. (2) (*d*) of this section or where there shall be exceptional circumstances as regards volume or quality or otherwise.

Right to call for modification of regulations.

12. Either the Corporation or any trader affected may from time to time serve on the other of them two months' notice of their or his desire to modify vary, or rescind any general or special regulations which may be deemed to have become unnecessary or undesirable and substitute further or other regulations, but such modification, variation, rescission, or substitution shall be settled with due regard to all and every the matters mentioned or referred to in Sub-secs. (2) (3) and (4) of the section of this Act the marginal note of which is "Corporation shall make General Regulations" and shall failing agreement be settled in manner provided by the section of this Act the marginal note whereof is "Reference of questions in dispute."

Reference of questions in dispute.

13. Until Parliament otherwise provides any question arising under this part of this Act or under any regulations made thereunder shall if the parties so agree be referred the Local Government Board for determination otherwise than as arbitrators or if they do not so agree then to arbitration under the provisions of the Arbitration Act, 1889. On any reference to the Local Government Board under this section that Board may make such order in the matter and as to the costs of the reference and of the parties as to the Board may seem equitable and the order so made shall be binding and conclusive on all parties.

Expenditure to be included in "other expenses" within interpretion of "net annual value."

19. In the assessment of the annual value of trade premises for rating purposes any expenditure under this part of this Act required to be incurred by the trader to enable such trade premises to fulfil the requirements of any regulations for the time being in force with respect to such premises shall be deemed to be included in the words "other expenses" in the interpretation of the words "net annual value."

Considerable difficulty has been experienced by the traders in the West Riding, more particularly in years gone by, in obtaining scientific information as to the best means of dealing with their trade refuse, and the Association would welcome the appointment of a Central Authority, fully equipped with scientists, to advise on this subject. The Association feels that this is the only satisfactory solution of the difficulty of dealing with the positions which arise from time to time in connection with trade waters.

The traders also feel very strongly that this Central Authority should deal with all differences which arise between traders and sanitary authorities.

They are also of opinion that standards are desirable, and that they should apply uniformly to all persons and firms engaged in the same trades, without regard to the river or stream upon which they may be situate, as an uniform treatment is important, and can only be arrived at in that way.

The standards should, in the first instance, not be too high, but should be attainable by all traders at reasonable cost.

After further knowledge has been gained upon the subject by both traders and a Central Authority, it may and probably will be, found possible to improve the standard of purification.

I have given consideration to the question of districts, and if Rivers Boards are to be established throughout the country, it seems desirable that their districts should be fixed by watersheds, and not necessarily by existing boundaries of districts.

The duties of Rivers Boards should be limited to inspection and prosecution, and the traders of the West Riding would not be satisfied to have a Rivers Board set up as an authority to deal with matters in dispute. They would much prefer to deal directly with a Central Authority.

Neither Local Authorities nor Rivers Boards should have the power of controlling the erection of new works or the alteration of existing works, except, so far as Local Authorities are concerned, the power of approving plans conferred by the Public Health Act, 1875. The standard of effluent discharged from those works in compliance with the Regulations should be the only matters with which they should be empowered to deal.

The traders in the Borough of Halifax connect to the sewers of the district without any treatment, and make a money payment in lieu of preliminary treatment.

The same principle has been adopted in Huddersfield, and the following terms have been arranged:—

(1) The payment by the traders of 1d. per 1,000 gallons of trade effluent discharged into the Corporation sewers for the first three years, whatever sum that price may produce.

(2) After three years there are to be abatements in case 1d. per 1,000 gallons would produce more than £3,000 a year, such abatements to continue until the price charged shall be reduced to 0·6d. per 1,000 gallons when the flow reaches 4,000,000 gallons per day.

(3) Thereafter the charge to be uniform at 0·6d. per 1,000 gallons whatever the flow.

(4) The Corporation not to receive more than £3,000 a year until after the price per 1,000 gallons is reduced to 0·6d. except in the first three years, when there will be no limit to the sum they may receive.

(5) That the manufacturers take immediate steps to remove such clean water as practicable, and failing such removal must pay the rate of 1d. per 1,000 gallons.

(6) A joint committee to be appointed, four from the manufacturers and four from the Corporation, for the purpose of arranging details and settling all matters in dispute between both parties.

On behalf of the members of the Association, I approve of the Evidence which has been given by the Witnesses representing that body.

Mr. John H. Hanson, Mr. Alfred Sykes, J.P., Mr. Charles Mills, and Mr. Thorp Whittaker.

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MEMORANDUM PREPARED BY MR. CHARLES MILLS, OF HUDDERSFIELD, SOLICITOR TO THE ASSOCIATION.

The above Association was formed in June, 1897, its objects being:—

> "To watch over, protect, and promote the interests of the members whose works are affected by the Rivers Pollution Act, 1876, The West Riding of Yorkshire Rivers Act, 1894, and other Acts relating to the fouling of rivers by trade refuse, and to obtain information generally on the subject, both as regards liability and the best means of dealing with the question."

The Clerk and Engineer to the Association can give information as to the membership of the Association.

I have acted as solicitor to the Association since its formation up to the present time, and have been present at most of the Local Government Board Inquiries held during that period, and have acted for the Association in nearly all their cases which have been tried in the County Courts; and those on appeal to the Divisional Court; the Court of Appeal; and the House of Lords.

I have read a print of the evidence given by Mr. Atter, the clerk and solicitor to the West Riding of Yorkshire Rivers Board, before the Commission, but before dealing with it I think it desirable to point out the anomalies of the existing law as it affects trade effluents.

There are two Acts in force in the West Riding, the General Act of 1876, and the Act of 1894, which applies to the West Riding alone.

These Acts are almost identical in their provisions, the principal difference between them being, that under the Act of 1876 the proceedings for offences are taken in the County Court, whilst under the Act of 1894 they are taken in a Court of Summary Jurisdiction.

The latter Act, however, gives the officers of the Rivers Board power to enter premises for the purpose of taking samples, a power which is not given by the earlier Act.

I shall have to refer to this power when I come to deal with Mr. Atter's evidence.

During the early years of its existence the Rivers Board proceeded under the powers of their own Act, and instituted proceedings before the Justices, but in later years they have, except in a few cases, taken proceedings in the County Court under the Act of 1876.

The objection to this alternative jurisdiction is that it enables the Rivers Board to elect as to which tribunal they will resort in any particular case, and the fact of their having in some cases preferred a tribunal of Justices, whilst in others they have resorted to the County Court, has created dissatisfaction in the minds of manufacturers and their advisers.

Both the General and the Local Act contain an identical provision requiring every sanitary or other local authority having sewers under their control, to give facilities enabling manufacturers within their district to carry liquids proceeding from their factories or manufacturing processes into such sewers, subject to such liquids not being of such a nature as to prejudicially affect the sewers, or the disposal by sale, application to land or otherwise, of the sewage matter conveyed along such sewers, or which would from its temperature or otherwise be injurious in a sanitary point of view.

The construction of this section has recently given rise to litigation in the case of *Brook* v. *Meltham Urban District Council* (1908) 2 K.B. 780. Messrs. Brook are large cotton thread manufacturers at Meltham Mills, which is within the urban district of Meltham in the West Riding. The Rivers Board having taken proceedings against them for discharging their trade liquids into the river, they applied to the District Countil for facilities under Sec. 7 of the Act of 1876, and as these facilities were refused on the ground that the Council did not wish to receive trade effluents into their sewers, Messrs. Brook applied to the County Court for an Order requiring the Council to give them the required facilities.

It was admitted on the hearing of the application that the Council's sewer pipes were amply sufficient for the reception of Messrs. Brook's effluent in addition to domestic sewage, and that such effluent would not contravene the provisos to Sec. 7, but they opposed the application on the ground that the Council's purification works were inadequate to treat both the domestic sewage and Messrs. Brook's trade liquids.

It was contended on behalf of Messrs. Brook that the word "sewers" in Sec. 7 must be construed in accordance with the provisions of the Public Health Act, 1875, which throughout distinguishes outfall works from "sewers," and that as the latter were admittedly more than sufficient for the requirements of their district, the Council were bound to give the facilities asked for. On the other hand it was contended by the Council that "sewers" included outfall works, and that as these were not sufficient to treat both sewage and trade liquids, Messrs. Brook were not entitled to such facilities.

The House of Lords have decided in favour of the latter contention, thus overruling the decision of the Court of Session of Scotland in the case of *Guthrie* v. *Magistrates of Brechin*, 15 Ct. Sess. 385, in which it was held that outfall works do not form part of the sewers, and that the measurement of capacity referred to in Sec. 7 is the capacity of the pipes to receive both the sewage and the trade liquids.

The decision of the House of Lords enables local authorities, by limiting the capacity of their outfall works, to escape from affording the facilities which the Act intended to secure to manufacturers.

Another contention has, moreover, been raised, which would virtually repeal the section by making worthless any order for facilities which might be obtained. I refer to the case of *The West Riding Rivers Board* v. *Butterworth and Roberts* (1909) A.C. 45, in which Lord Macnaghten expressed the opinion that such an Order would be no answer to proceedings for pollution, there being nothing in the Act to make the Order a good defence.

I have referred to these matters as showing the necessity which exists for an amendment of the present law, and as the Commission may desire, or be willing, to consider any suggestions for such amendment, so far as it affects trade effluents, the Association respectfully submit the following for their consideration.

1. It is now generally admitted that trade effluents should be received into the public sewers subject to preliminary treatment, although the local authorities of some districts are unwilling to incur the cost of purifying the effluents.

The Association share the view which is stated in Par. 22 of the Third Report on the Treatment and Disposal of Sewage, viz.:—that the law should be altered so as to

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make it the duty of a local authority to provide such sewers as are necessary to carry trade effluents as well as domestic sewage and to purify them.

The present position is anomalous and unjust, as is shown by the fact that in every district some manufacturers already discharge their effluents into the sewers without preliminary treatment and without expense to themselves, whilst their neighbours and competitors in trade are denied the same privilege by the local authorities, and have been compelled to expend considerable sums in constructing purification works, whilst their more fortunate rivals have escaped the attentions of the Rivers Board.

This undue preference is referred to in Pars. 16 and 34 of the Third Report, in which it is stated that, as far as practicable, manufacturers should be placed on the same footing, and that their proposals should apply equally to the manufacturer whose trade effluent already passes into the sewer, and to the manufacturer who is only proposing to obtain a connection.

2. How should Trade Effluents be dealt with ?

In considering this question it is necessary to discriminate between the varying conditions under which manufacturers obtain their water supply, and deal with their liquids.

Where such supply is obtained from a stream they are, as is pointed out in Par. 31 of the Third Report, precluded from discharging their effluent into a sewer (unless, I may add, a prescriptive right to do so has been acquired) by reason of the obligation which rests upon them of returning the water into the stream.

Where, however, the water supply is obtained from private wells, or from other sources, there is nothing to prevent the discharge of the effluent into a sewer upon such terms as Parliament may deem equitable.

It will, therefore, be necessary to distinguish, and to provide separately for, the cases in which the water supply is obtained from a stream, and those where it is obtained from other sources.

Where the water is required to be returned into a stream, the question as to compliance with the standards of purity will be one between the trader and the Rivers Board, whilst in the other cases the question will be one between him and the local authority.

As regards the discharge into a stream, it is submitted that standards should be fixed by the Central Authority, which it is proposed to establish, fixing definite standards of purity for the different trades, subject, however, to their being varied or dispensed with altogether in special cases. (Par. 22 of the Third Report.)

Liquids which merely occasion innocuous discolouration not to be deemed polluting.

The absence of such standards has caused difficulties and dissatisfaction by reason of the fact that after providing purification works, a manufacturer is nevertheless subject to proceedings by the Rivers Board on the ground of alleged inefficiency.

The procedure which the Association suggest is as follows :—

Before proceedings are taken, for the first time, for the recovery of penalties, a notice should be served upon the person against whom it is proposed to proceed, requiring him to observe the standard of purity applicable to his manufactory, within a time to be specified in such notice but not being less than two months.

Such person should have a right to apply to the Central Authority either to dispense with, or to vary the standard in his particular case, if it be shown that means for observing it are not, having regard to the reasonableness of the cost and the effect on his business, reasonably practicable and available under all the circumstances of the case. (Act of 1894, Sec. 11 (5).)

Where the standard is not dispensed with but merely varied, the Central Authority should have power to fix the period within which the standard, as varied, should be observed.

Penalties should be imposed for the non-observance of the standards, and it is suggested that those fixed by Sec. 12 (1) of the Act of 1894 are reasonable and should be adopted in preference to the excessive penalty of £50 a day fixed by the Acts of 1876 (Sec. 10) and 1894 Sec. 12 (3).

These penalties should be recoverable before a Court of Summary Jurisdiction.

A right of appeal should be given to either party both on the law and the merits, by way of a special case. (Summary Jurisdiction Act, 1879, Sec. 33.)

Where the water need not be returned into a stream, it should be made obligatory upon local authorities to receive and dispose of trade liquids, subject either to preliminary treatment or to payment.

The advantage of a money payment, in lieu of preliminary treatment, is that it saves the cost of providing and working separate purification plants at each manufactory (which in themselves cause a growing sentimental grievance by their hideous appearance), whilst the total quantity of the trade effluents in a district could, in conjunction with domestic sewage, be purified by the local authority more efficiently and without undue cost to the ratepayers.

I may mention that at Halifax a scale of charges has been agreed upon between the traders and the Corporation, on payment of which the Corporation receive and treat the effluents without preliminary treatment.

Power should, therefore, be given to local authorities to dispense either wholly or partly with preliminary treatment, and to receive a money payment in consideration thereof.

Where no such arrangement is made, then preliminary treatment should be required, and general regulations should be framed by the Local Authority and confirmed by the Central Authority, and provision should be made (as suggested in Par. 22 of the Third Report) as to varying these Regulations to meet particular cases.

The Association recognise the desirability of such Regulations providing for the exclusion from sewers of :—

(*a*) All solid matter.

(*b*) All water which is not of a poisonous, polluting, or noxious nature.

(*c*) Any liquid which would prejudicially affect the sewers.

(*d*) Any waste steam, condensing water, heated water or other liquid (being of a higher temperature than 110 degrees Fahrenheit) which either alone or in combination with the sewage would cause a nuisance or be dangerous or injurious to health.

The Association are of opinion that the duties of Rivers Boards should be purely administrative, and that the settlement of the differences mentioned in Pars. 56 and 57 of the Third Report should not be entrusted to them, but to the Central Authority, unless the parties agree upon an arbitrator. The objection is, that it is not deemed wise or expedient to devolve the settlement of such differences upon a body upon whom rests the duty of enforcing the provisions relating to pollution.

Mr. Atter's Evidence.

I now proceed to deal with the suggestions made by Mr. Atter with the view of obtaining for Rivers Boards additional powers.

New Sources of Pollution.

Mr. Atter suggests that every person who intends to carry on any business from which liquid refuse might be discharged into a stream should be required to notify his intention to the Sanitary Authority and the Rivers Board, specifying what steps he proposes to take to prevent such liquid polluting the stream, and that either of those authorities should have power to disapprove the proposals, subject to appeal to the Central Authority. He cited in support of the proposal the powers given under the following Acts :—The Lee Conservancy Act, 1868, Sec. 91 ; Thames Conservancy Act, 1894, Sec. 93 ; Middlesex County Council Acts, 1898, Sec. 12 ; and 1906, Sec. 10 ; and Alkali Works Regulations Act, 1881, Sec. 12.

I think it doubtful, however, whether those Acts give the power which the Rivers Board desire to acquire.

The Lee Conservancy Act, 1868, Sec. 91, prohibits the opening into the river any channel for the carrying of "sewage or other offensive or injurious matter" which may not include trade effluents, as the words "other offensive matter" may only include matter which is *ejusdem generis* with "sewage." This construction is supported by the marginal reference to Sec. 92, which is "Notice for discontinuance of existing sewage works."

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The same words are used in The Thames Conservancy Act, 1894, Sec. 93, and the Middlesex County Council Act, 1898, Sec. 12; and that they do not include trade effluents is, I think, shown by the fact that in the Middlesex Act of 1906, Sec. 10, the discharge of trade liquids into a stream is expressly prohibited, which prohibition was altogether unnecessary if such liquids were included in the words "other offensive or injurious matter."

But whatever may be the correct interpretation of those Acts, the power of preventing or regulating the establishment of new manufactories is strongly objected to. It was embodied in Sec. 44 of the Rivers Board's Bill of 1905, and was petitioned against by the following Corporations and traders:—

Traders carrying on business at Huddersfield, Halifax, the Colne, Holme, and Spen Valleys, Dewsbury, Heckmondwike, Mirfield, Batley, Morley, and Farsley; and also by the following:—

The Bradford Dyers' Association, Limited.
Woolcombers (Limited).
The Bradford Corporation.
The Leeds Corporation.
The Leeds Woollen and Worsted Manufacturers' Association.
The West Yorkshire Coal Owners' Association.
Earl Fitzwilliam.
The Mining Association of Great Britain.
The Pudsey Corporation.
Bradford Traders.
Mill-owners, Lessees, and Occupiers on the River Don.

Abuse of Purification Works.

The Association recognise the difficulty referred to by Mr. Atter, in cases where purification works have been provided, but are not properly used, and they suggest that it might be met by making the occupier liable, giving him, however, the benefit of a provision similar to that contained in Sec. 141 of the Factory and Workshops Act, 1901, which enacts:—

> (1) Where the occupier of a factory or workshop is charged with an offence against this Act, he shall be entitled, upon information duly laid by him, to have any other person whom he charges as the actual offender brought before the Court at the time appointed for hearing the charge; and if, after the commission of the offence has been proved, the occupier of the factory or workshop proves to the satisfaction of the Court:—
>
> (*a*) That he has used due diligence to enforce the execution of this Act; and
>
> (*b*) That the said other person had committed the offence in question without his knowledge, consent, or connivance, that other person shall be summarily convicted of the offence, and the occupier shall be exempt from any fine. The person so convicted shall, in the discretion of the Court, be also liable to pay any costs incidental to the proceedings.
>
> (2) When it is made to appear to the satisfaction of an inspector at the time of discovering an offence:—
>
> (*a*) That the occupier of the factory or workshop has used all due diligence to enforce the execution of this Act; and
>
> (*b*) By what person the offence has been committed; and
>
> (*c*) That it has been committed, without the knowledge, consent, or connivance of the occupier and in contravention of his orders, the inspector shall proceed against the person whom he believes to be the actual offender without first proceeding against the occupier of the factory or workshop.

Short Tenancies.

The Association agree with Mr. Atter that some relief ought to be afforded to a tenant who is ordered to provide purification works, and they suggest that power should be given to a tenant who alleges that the owner ought to bear or contribute to the expenses of complying with the order, to apply to a Court of Summary Jurisdiction, which, after hearing the owner, may make such order as appears to the Court just and equitable, under the circumstances of the case, regard being had to the terms of any contract between the parties. (*See* Secs. 14 (4) and 101 (8) of the Factory and Workshop Act, 1901).

Liquid Refuse dealt with by Contractor.

The Association do not object to the Rivers Board's suggestion.

Samples.

Mr. Atter cited the Alkali, Thames, and Middlesex Acts as precedents justifying his proposal for power being given not only to enter upon but to lay open trade premises for the purpose of taking samples.

All, however, that the Alkali Act empowers is an entry upon premises for the purpose of inspecting any process which is being carried on. It does not authorise the taking of samples.

As regards the Thames Act, it refers, as I have pointed out, to sewage and not to trade effluents; whilst the Middlesex Acts do not empower the laying open of premises for the purpose of taking samples (Sec. 14 of Act of 1898), but power is given by that section as extended by Sec. 7 of the Act of 1906, to take samples not only at the point where it passes into a stream, but also at the point from which it flows into a stream, whether directly or through, across or under, other lands or premises; and the Association do not object to a similar power being conferred upon Rivers Boards.

Discharge by Joint Outlet.

The Association do not object to power being given to take samples of the trade effluents which are discharged from all or any of the premises into a drain, where more than one trader discharges his liquid through one outfall or drain, at the point of outlet into the joint drain, and to take proceedings against the offenders jointly or individually.

Procedure.

As already stated, the procedure under the Act of 1876 is in the County Court, whilst under the Act of 1894 it is before a Court of Summary Jurisdiction.

In the procedure suggested by the Association no application for orders to abate pollution will be required, and legal proceedings will be limited to the recovery of penalties, which it is suggested should be recoverable summarily. The objection to their being recoverable in a County Court is the great expense involved in proceedings in it, and moreover, it is usual to make penalties recoverable before Justices (Public Health Act, 1875, Sec. 251; the Factory and Workshop Act, 1901, Sec. 144; the Middlesex County Council Act, 1906, Sec. 41; the Thames Conservancy Act, 1894, Sec. 201;) and this method of recovery is that prescribed by the West Riding Rivers Act, 1894, Secs. 12 and 13, which were incorporated in the Rivers Board's Bill of 1905, Sec. 47.

It might, however, be provided, as in Sec. 144 (4) of the Factory Act, that the occupier (or his father, son, or brother) of the premises in or with reference to which an offence is alleged to have been committed, might not act as a member of the Court hearing a proceeding with respect to that offence; nor (Sub-sec. 5) might a person so act, who is engaged in, or who is an officer of any Association of persons engaged in the same trade or occupation as a person charged with such offence.

Proceedings against Firm.

The Association have no objection to proceedings being taken in a firm's name.

Assessment of Annual Value.

A provision should be made similar to that contained in Sec. 19 of the Huddersfield Corporation Act, 1906, which is as follows:—

> "In the assessment of the annual value of trade premises for rating purposes any expenditure under this part of this Act required to be incurred by the trader to enable such trade premises to fulfil the requirements of any regulations for the time being in force with respect to such premises shall be deemed to be included in the words 'other expenses' in the interpretation of the words 'net annual value.'"

Summary of Suggestions.

1. That it should be made the duty of the local authority to provide sewers for the reception of trade effluents.

2. That trade effluents should be dealt with as follows:—

(*a*) Where the water has to be returned into a stream, and where, consequently, the manufacturer

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is precluded from discharging his effluent into a sewer, the obligation should be to comply with the standards of purity, but provision should be made for varying or dispensing with them in special cases.

(*b*) Liquids which merely occasion innocuous discolouration not to be deemed polluting.

(*c*) Where the effluent is, or can be, lawfully discharged into a sewer, it should be obligatory upon the local authority to provide such sewers as may be necessary to receive the effluent, subject either to preliminary treatment or payment in lieu of such treatment.

(*d*) Regulations should be made by the local authority and confirmed by the Central Authority, fixing definite standards of purity for different trades, and provision should be made for varying or dispensing with them in special cases, subject to a money payment in consideration thereof.

(*e*) Power should be given to local authorities to receive a money payment in lieu of preliminary treatment, and such payment should be compulsory where the Regulations are either varied or dispensed with.

(*f*) Such Regulations should provide for the exclusion of:—

(1) Solid matter.

(2) All water which is not of a poisonous, polluting or noxious nature.

(3) Any liquid which would prejudicially affect the sewers.

(4) Any waste steam, condensing water, heated water, or other liquid (more than 110 degrees Fahrenheit) which either alone or in combination with the sewage would cause a nuisance or be dangerous or injurious to health.

3. That the duties of Rivers Boards should be purely administrative.

4. That all differences between local authorities and manufacturers should be settled by the Central Authority, unless the parties agree to an arbitrator.

5. That before proceedings are taken for the first time for the recovery of penalties, a two months' notice should be given to the manufacturer intended to be proceeded against, who should have a right to apply to the Central Authority to dispense with or vary the standard of purity in his case, if it be shown that means for complying with it are not, having regard to the reasonableness of the cost and the effect on his business, reasonably practicable and available under all the circumstances of the case.

6. That power to control the establishment of new manufacturing business should not be vested in either Rivers Board or local authorities.

7. That in cases of the abuse of purification works, the employer should be liable to penalties, power however, being given to them to bring before the Court the actual offender in the same manner as under Sec. 141 of the Factory and Workshop Act.

8. That in the case of short tenancies power should be given to the tenant to apply to a Court of Summary Jurisdiction to make an Order upon the owner to contribute an equitable proportion of the cost of providing purification works, regard, however, being had to the terms of any contract between the parties.

9. That the manufacturer should be liable where he disposes of his liquid refuse to an independent contractor who discharges it into a stream in such a state as to pollute it, unless the manufacturer produces to the Rivers Board a written agreement showing that the contractor has undertaken to deal with the refuse so as not to cause pollution.

10. That Rivers Boards should have power to take samples in like manner as under the Act of 1876 (but not to lay open manufacturing premises) not only at the point where the effluent passes into a stream, but also at any point from which it flows into a stream whether directly or through, or across or under other lands or premises.

11. That power should be given to take samples from any premises where more than one trader discharges his liquid through one outfall or drain, and to take proceedings against the offenders jointly or severally.

12. That penalties should be recoverable summarily. Power of appeal by special case to be given on the law and the facts.

13. That power be given to proceed against a firm in the firm's name.

14. Expenses incurred by a trader to comply with the standards or preliminary treatment, to be allowed in assessing the annual value.

29243. (*Chairman.*) Now, I think I will ask Colonel Harding to put questions.

29244. (*Colonel Harding.*) The Commission have had the advantage of hearing evidence from the officers of the Mersey and Irwell Rivers Board, the Ribble Joint Committee, and the West Riding of Yorkshire Rivers Board. They have also had the advantage of hearing evidence from the manufacturers in the Lancashire district, and I am sure I am speaking for my colleagues, as well as for myself, when I say we are very pleased indeed to meet the representatives of your Association. I take it from Mr. Hanson's Statement that you have 241 members ?—(*Mr. Hanson.*) That is so.

29245. At the present time ?—That is so.

29246. Would you tell us whether those members include a variety of trades ?—They do ; they include all the branches of the woollen and worsted industry. That is, those who are dyers only, those who are finishers only, those who are dyers and finishers, those who scour wool, and those who scour pieces.

29247. Then we may take it your members are all connected in some way with the worsted and woollen trades ?—That is so.

29248. And are the 241 members fairly representative of the whole of those trades ?—I think they are ; yes.

29249. They include the more important firms ?—They do ; they include the larger firms.

29250. I suppose the uncertainty of legislation in regard to the responsibilities of manufacturers and local authorities has been hitherto a very great difficulty ?—It has been a very great stumbling block.

29251. And has probably led to the friction that I see some of you have alluded to between manufacturers and the Rivers Board ?—Undoubtedly.

29252. I notice you generally agree with what this Commission has said in its hitherto published Reports, as to the advisability generally of local authorities dealing with trade effluents where that is practicable ?—That is so.

29253. And we are pleased to see that your Association has accomplished much in bringing about an arrangement between manufacturers and the local authorities in Halifax and Huddersfield, and in Heckmondwike ?—That is so.

29254. And I suppose you would agree with me if I say that the effect of having brought about those arrangements is to facilitate similar arrangements in other directions ?—There is no doubt it will.

29255. It forms a sort of basis ?—It does.

29256. And speaking generally the arrangement with these important authorities is on the basis of their taking the trade effluents, subject to certain conditions as to preliminary treatment, and failing such conditions as to preliminary treatment, of payment in lieu thereof ?—That is so ; that is the principle.

29257. Your Association evidently recognises that if trade effluents are to be taken into sewers, it is generally desirable in the first instance to eliminate suspended matter as far as possible ?—It is.

29258. And grease ?—Yes.

29259. But there are cases probably where a manufacturer, not having room on his premises to adequately carry out such preliminary treatment, thinks it advisable that a money payment should be substituted ?—In practice in the larger towns or sanitary districts I think it will be found that the trader will elect to pay rather than enter upon the preliminary treatment.

29260. In many cases you think they would be obliged to do that ?—In many cases they would be obliged. I mean there are cases where they could not possibly put down a plant without disturbing machinery.

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29261. And the nature of the payment which is to take place is in substance agreed ?—In the case of Halifax and Huddersfield it is agreed.

29262. But I suppose, after local authorities have taken all that it is practicable to take, there will remain and must remain a number of cases where a manufacturer will have himself to purify his effluents ?—There will be quite a number of cases where the manufacturer cannot divert the water.

29263. Where he is obliged to return the water to the river ?—Where he is obliged to return the water to the river, and in those cases he will have to carry out the treatment himself.

29264. Then there must be also cases where it is not practicable for the local authority to receive the trade effluent into their sewers, possibly because of its large volume ?—I have no doubt cases of that sort will arise. At present, in the experience of our Association, that position has not arisen, but still throughout the country I have no doubt it will.

29265. Do I understand that in your district the difficulty has not arisen, that the authority has declined to take effluents because of the relatively large volume of them ?—I do not know of a single case, excepting this; they have objected in cases where their existing outfall works have been insufficient, but I take your question to go beyond that, and apply to cases where they cannot extend their outfall works. No such case as that has arisen that I remember at the moment.

29266. You find in the West Riding generally that the local authorities now are much more willing than they were to take trade effluents ?—Since those three Acts of Parliament have been passed I think one may claim that is the position.

29267. Then if difficulty should arise as between manufacturers and local authorities, you suggest that the Central Authority which this Commission has proposed to have established would be very useful for referring disputes and getting a settlement ?—We think, and we feel this very strongly, that if, say, when the 1894 West Riding Act was passed there had been then an authority to which the traders could have applied for information and guidance, the progress towards purification of the rivers would have been much quicker, and a great deal of friction which has arisen, would not have arisen.

29268. But has not that friction been largely due to the uncertainty of legislation in regard to the responsibilities of manufacturers and local authorities ?—Yes, largely, but also in part through the lack of knowledge and experience as to how to begin to treat the trade refuse. Get back to 1894 or 1895, when the Rivers Board themselves had not—speaking with all respect—within their own department, experience on this question; they could not possibly have; say you establish a Rivers Board on the Bradford Avon to-morrow. Well, you would get members of the Board elected from the various authorities as they are in the West Riding. They would appoint an inspector and officials. Well, in 1894 they had not the choice, the men were not there—the officials who had expert knowledge on this particular subject—therefore they did the best they could, and those officials have had to educate themselves, just as the traders have had to educate themselves, on this subject from that time up to a few years back.

29269. Then the conditions at present are somewhat different from what they were when the Board was first established ?—The conditions are all altered. I mean, the traders in the West Riding have a more intimate knowledge of this subject, of how to deal with their trade waters, knowledge they had not at all in 1894; officials, and all of us, know more about it than we did in 1894, because we have all been concentrating attention on the subject.

29270. And the same thing applies to the Rivers Board ?—That is so.

29271. They have now officials who have acquired very considerable knowledge of the treatment of the effluents, and who have acquired a very considerable knowledge of their district ?—That is so.

29272. I notice that with regard to procedure, you desire to limit the Rivers Board to administrative action, and you suggest that if there is power in the case of disputes to refer matters directly to the Central Authority, it will cause less friction than referring them in the first instance to the Rivers Board of the district ?—I think it will.

29273. Would you explain to us quite why, because it seems to me at least that these difficulties will arise, will they not, with the Central Authority in the same way as they do with the Rivers Board, and that if they were dealt with by the local body first, with power of appeal to the Central Authority, it would be a more convenient plan ? What is the objection to it ?—The traders think it would not be more convenient, and for these reasons. In the first place the Rivers Board does not appear to have power to engage in any experiments; therefore, their officials only obtain knowledge from the experiments of others, whereas a Central Authority, I presume, would have officials who themselves were experts on this subject. They would be acquiring also knowledge from the experience of the whole country. They would, therefore, be able to continue on one uniform line throughout the whole country, whereas if Rivers Boards—I am now referring more particularly to the technical points—were dealing with technical points there would probably be a variety of lines of action, the advice not necessarily being consistent. That is the first point. The second point is that the Rivers Board is in itself a prosecuting authority, otherwise it seems to me it would not be necessary for it to exist at all alongside the Central Authority. Now, it is not desirable in the interests of the trade of the district that a prosecuting authority should be the authority to whom of necessity disputes between the same parties should be referred. Those are the two principal objections. I took up that position when the Huddersfield Bill was before the House of Commons, and it was suggested there by the Local Government Board, who pressed the point very much, that they should be the authority to whom all disputes should be referred. On behalf of the traders I objected to the Local Government Board, on the ground that they had not the officials who were experienced in the subject, and, therefore, were not fully qualified to deal with all matters of dispute. But I further took up the position that if a Central Authority was instituted, such as is foreshadowed in your Third Report, to that authority the traders would gladly submit their disputes. That was my position.

29274. The Commission, of course, are with you to a great extent, and have, in fact, recommended the formation of such a Central Authority, but I was rather trying to get from you whether in view of there being in your own locality a body which has now undoubtedly acquired very large experience in these matters, and which has a staff of officials and laboratories at Wakefield, whether they might not, in the first instance, save a great deal of expense and trouble in going to the Central Authority, and be able to settle a great many matters, referring only those where their decisions were not accepted. Is there anything in the constitution of the local Rivers Board which makes it unlikely, in view of their acquired experience, that they will be able, in the first instance, to settle a great many matters between manufacturers and local authorities without reference to the Central Authority ?—We think that matters that they could settle without reference to a Central Authority might safely be left to the trader and the sanitary authority with whom the trader is dealing, but if the trader and the sanitary authority cannot agree upon any point, the traders feel very strongly that they must then go to an authority which has the best information and knowledge on the subject that exists in the country. The traders themselves, you know as well as I do—especially the dyers—are practical chemists, all of them. All those who have put down plants—and this is where so much information has been brought to light—have studied it, and considered it, and are constantly developing it, looking out for improvements; and that is the way the Rivers Board officials have to gain their knowledge. They have no other means of gaining it, except gaining it from the traders. Assume for a moment that they could get no information from traders or traders' plant, they would be practically where they were in 1894, so that the trader would not feel much confidence in referring a dispute which he had between the sanitary authority and himself to anything less than the highest authority.

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29275. Well, we take that as your view of it. Now, as I say, your Association seem to have accomplished extremely useful work, in bringing about those arrangements with local authorities, but it seems to some of us that those Associations of Manufacturers can also carry out most useful work in endeavouring to assist their members to find out what is the best way to meet their difficulties. One appreciates, of course, that a manufacturer engaged in this business has not possibly the necessary technical chemical information which enables him to carry out efficient works, and has not the leisure to give attention to it; and, therefore, it would be of very great value if an Association like yours were to make a special study, in the interests of all the members, of the difficult points in connection with trade effluent treatment. Would you be good enough to tell the Commission what steps, if any, your Association has taken in that direction?—The principal work of the Association—I think I may divide it into two classes—has been first of all to endeavour to find the legal position. The second is that they have been endeavouring to find the practical means of dealing with their trade waters, and in order to do that the Executive Committee have visited practically every works they could hear of, which they were led to believe were worth visiting.

29276. Not only in the West Riding?—Not only in the West Riding, but throughout the country. They have then made Reports, which Reports were made in writing to the whole Committee, and whenever a trader has commenced to put down plant he has had the benefit and the advantage of the recommendations of the Executive, who had viewed the works that exist that were worth visiting. That really is what has brought into existence the plants which have been put down by the members of this Association, in some of them the very highly efficient manner in which they have been put down. From time to time difficulties are constantly arising; as those difficulties arise with one member of the Association, the matter is considered by the Committee, and if any other trader has found out a means of dealing with that difficulty, the information is conveyed to him, so that what they have been doing at the present time is collecting the information that could be got, and distributing it amongst the members.

29277. I see that in your evidence, Mr. Hanson, you refer to a correspondence with the Rivers Board, in which you asked, so long ago as 1898, to be informed as to where efficient purification plant could be seen. You have received a reply to that communication, and I gather from what you say that your Association visited those places and made a Report. That Report would be extremely interesting to us. Is it available?—Yes, we have the Report. A Report was made on each of those four mills which were referred to by Dr. Wilson. That Report was considered by the Executive, and points that commended themselves in those plants were then conveyed to members of the Association for their use as they had to put down plants.

29278. The Report is in existence?—It is; yes.

29279. Would it be possible for you to put that Report before us?—Well, that I will submit to the Executive Committee, and ask their instructions.

29280. It would be rather interesting to us to see what opinion your Association formed in regard to those particular works to which you have referred, and the nature of the advice you gave to your members.—That I will submit; I will take the instructions of the Executive Committee.

29281. There has been no Report published, has there, by your Association?—Oh, no, none.

29282. Now, what works have been carried out in consequence of those Reports in your district among your members?—What do you mean; in consequence of those particular Reports?

29283. I gathered, from what you said just now, that you reported to your members, and gave certain advice to some of them, and as a consequence certain works have been carried out?—Yes.

29284. Can you refer us to any of them?—Well, I cannot specifically, because the particular point that struck the traders as being good in this way would in some cases be probably the only point that commended itself in the works that were visited, and these were all put together; I mean put together in this way. Say there was an Order made against a trader. He came to us and said: "I shall have to carry out Purification Works. What lines must I go upon?" Then the effect of the collected information would be conveyed to him according to his trade waters, and what his refuse consisted of. None of those have been published. They have been conveyed personally to the traders from time to time as the trader required it. Since 1898, of course, many great improvements have been made in the method of dealing with the different classes of trade refuse. What was probably considered a decent plant, a reasonable plant, in 1898, probably the Rivers Board would by no means look upon as such to-day; and certainly the traders would not look upon that as the best type of plant to put down having regard to the future.

29285. You have told us, and we quite appreciate that it has been necessary, that the attention of your Association has been largely directed hitherto to elucidating the legal aspects of these matters?—Yes.

29286. But I should like, if possible, to get from you some idea of what progress has been made, and how far your Association has been able to promote that progress in the treatment of effluents?—Well, we have promoted it by eighty-seven members of the Association having put down plants, either wholly or partly dealing with their trade refuse, and in the evidence which we propose to submit to this Commission in October—there not having been sufficient time to get it ready for this date—we propose to deal—and I think probably this is the answer to your question—with typical plants of the members of the Association for the various trades, taking more than one plant in the same trade. We propose to take sample of the water first of all, give you particulars of the system of treatment, and then give you an analysis of the trade refuse before treatment, and an analysis of the trade refuse after treatment, and the cost both of capital and working, so that you may be able to get down to the cost of that particular method of treatment, of so much per 1,000 gallons to the trader. This has been very carefully thought out and discussed by the Committee. They felt they ought, so far as their experience goes and opportunity, to give all the information they have to this Commission, and we concluded that that was the most valuable form in which they could do it.

29287. Without doubt that information will be of very great value to us?—That would give you a description of plants at these particular works, particulars of their trade, the quantity treated, the capital cost, the annual cost of working, and the result of the outlay, by analyses before and analyses after.

29288. And you will doubtless refer us to certain places where we shall be able to see these works in operation?—Yes, certainly we shall. We propose to ask you to put them on your notes under figures, but we will supply you with the names of the firms.

29289. That will show us, I suppose, the present position which has been reached?—It will; you may take it of the whole of the branches of the woollen and worsted industry, and that is why—in endeavouring to do it in such a way that it will be useful—we have not been able to have it ready for this meeting.

29290. I suppose we may take it that your Association does recognise the very urgent necessity there is for improving the effluents beyond the point which has been reached at present?—Well, I do not know that I can say I agree with the latter part of your suggestion. I think we had better wait and see what points have been reached; I mean by those who are treating. If you refer to the fact that some are not treating at all, then yes, the Association does agree with that. All should deal with their trade refuse, but as to the standard which has been reached, I should prefer to leave that question over for the present.

29291. Am I to understand that you think that the standard which has been reached is a sufficient standard?—In some cases, we think, more than ought to be asked of the trader, and bearing on that will probably be the cost; because, given sufficient outlay, you can do a very great deal, but there is a point where cost would become a most important consideration to the trade.

29292. Clearly cost must be taken into account?—Yes.

29293. Financially practicable, what is to be done ?—Yes.

29294. But do you wish us to take it that in your opinion the degree of purification which has been attained in the treatment of effluents in these particular trades is a sufficiently good result ?—I think that some of them are more probably than this Commission will ultimately ask for.

29295. That they are too good, in fact ?—Well, they are too costly. I will just illustrate it by one that comes into my mind. There is a firm which I have in my mind, a Limited Company, a member of our Association, which is now dealing with its trade waters at a cost of just over 4d. per 1,000 gallons.

29296. Is there any objection to mentioning the name of the firm ?—At present I prefer not to. My only reason for not being willing to give the name is that we may have to give you instances where probably we should agree the treatment is not sufficient, and we do not think we ought to expose these firms at the present time to that position.

29297. But it would evidently be very interesting to us if you could point to some plant where you considered that the results were satisfactory ?—Are satisfactory ?

29298. Yes ?—I have no doubt that the report we shall make will convey that to you when we give the chemical information and the cost, but I give the cost of 4d. per 1,000 gallons for treating as being what, at any rate to my mind, at this moment seems more than a member can spend.

29299. You have without doubt acquainted yourself with the work which has been carried out in Lancashire ?—Yes.

29300. In connection with the treatment of effluents ?—Yes, I know quite a number of their works.

29301. Have you been able to form any opinion yourself as to whether any great improvement has taken place in Lancashire rivers in consequence of the action of the Mersey and Irwell Board and manufacturers ?—Well, of course, improvement must have taken place because so much solid matter has been taken out. As to whether that improvement is worth the cost is quite a different point. That is not part of my answer.

29302. I see in the evidence of Mr. Scudder, who is, as you know, one of the officials of the Mersey and Irwell Board, he makes this statement: "The result of the work of the Joint Committee has been a distinct gain to the manufacturer in many ways. Not only has there been an improvement in the condition of the streams, enabling the manufacturer to use the water, but by adopting processes of recovery and carefully attending to the details of the manufacturing processes, much saving of raw materials has been effected." And in the course of our visits to Lancashire we were able ourselves to obtain from manufacturers an expression of their appreciation of the improvement which had taken place in the streams, and the value of the improvement to themselves. Probably your Association themselves realise that where manufacturers are obliged to take their supply from the rivers, it is of importance to them as manufacturers that the water which they so take shall be as pure as possible ?—Well, that may be the opinion to-day, but in 1894 the traders of the Colne Valley—and you may take it that is a most important Valley in this country so far as the woollen and worsted industries go—the traders there would have preferred to be left with their water, filthy as it was, rather than have it dealt with by chemicals, and have to try and dye and carry out their trade with the changed chemical condition of the water as it would come to them. They expressed it, and I, on their behalf, expressed it at that time, that they would much prefer if their interest only had to be considered to be left as they were. Nine miles down the stream, when the river too often appears black, they could get their bright colours, because their foremen dyers knew exactly the material they had to deal with. Directly plants were put down in the upper reaches of the River Colne, we began to have complaints as to the acidity. The Rivers Board themselves complained; they wrote to us and complained of the acidity in the river. Well, that is a very great difficulty, and a most important matter to dyers who are dealing with this water every day, and have been all their lives, and the President, as a practical man, will be able to go into that, and give you his opinion on that point. To-day they are educated, but there must be something done.

29303. I am glad to hear you say that. Now the objection as to acidity, of course, is a grave one, one quite realises that, but that is due not so much to the treatment as to the imperfect character of the treatment, is it not ?—Yes, but you see you must always bear in mind that where a trader has to manage these works by his workmen, such material as he has at hand, you will not get that perfect treatment that you will in the laboratory, and also bear in mind the large quantity of water and the ever changing conditions of it in a works, so that you cannot get that degree of perfection in a works that you will get in a laboratory. And the point really is what is the point, where a trader has large volumes to deal with, that they can really expect him to attain. Of course, we quite know that acidity can be avoided. I now have in my mind a trader who has spent £3,000 in works. His great difficulty has been to get rid of acidity. I think he has succeeded.

29304. You think he has succeeded ?—I think he has succeeded.

29305. That is a case probably to which you could refer us ?—That is one of the cases of which we shall give you particulars.

29306. The treatment of your wool-washing waters, of course, is the difficulty, is it not ?—Yes.

29307. When I say you, I mean members of your Association ?—Certainly.

29308. You first of all extract the grease from these waters, I will not say as far as it pays to extract it, but as far as it is practicably possible to extract the grease, and that treatment necessarily leaves you with a very acid effluent ?—It does.

29309. In some cases that effluent has been neutralised by the addition of lime and other precipitants, and there has been passage of the resulting effluent from the tanks on to filters, and it would be interesting to us to know, if by means of such treatment, improved results have been obtained ?—We shall be able to give you some information on that point.

29310. In October ?—Yes. Of course, you quite know that the old system of cracking, as it was called, was a means by which the trader a generation back took out that which was profitable to remove, then he did nothing more than that. Of course, now we have had to go beyond that.

29311. Your Association appreciates that you must go beyond that ?—Well, we have already gone beyond that.

29312. I am very glad to hear it. Now, coming to a question as to what is to be aimed at, you have expressed an opinion in regard to standards, that whatever standards are set out the standard should be uniform for all traders in that trade ?—That is so.

29313. And you have advised that, in the first instance, the standard should not be too high ?—Of course, the foundation of success must be in this question that you must fix a standard that can reasonably be got by all traders so as to stop friction, so as to stop litigation and disputes, between those who have to carry out the Act locally and those who have to comply with it. Therefore it is important in the first instance that the standard should be one that can be reasonably attained by all traders, and then, as scientific knowledge is gained, further knowledge which it will be undoubtedly, when you get more plants down, we shall be constantly getting further knowledge as to how to do it, and how to do it probably in a way which may reduce the cost or not increase it. When we get to that stage, then it would be a reasonable thing to begin and reconsider the standard.

29314. I hear with much pleasure your expression of opinion that progress is likely to be made as experience is gained ?—Well, it is, and I will tell you why. You are going to have hundreds of traders by and by managing their plants, and they will want to manage them from the standpoint of least cost with efficiency, with the efficiency which they must attain, and as they find economical conditions in the production of cloth so they will in dealing with trade refuse in time.

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29315. Now, do you think it would be wise, in fixing a standard, to fix a standard which should be in the nature of one to be aimed at but not necessarily to be at once attained, would it be better to state what would be considered to be ultimately the standard to be aimed at and to give latitude to the supervising body, the Local Rivers Board, to modify that standard provisionally ?—I think the traders, even at the expense of having to aim a little high, would prefer to have a fixture rather than be left to the consideration of the local authority.

29316. Well, whatever standard were fixed, if it were the moderate standard that you suggest as immediately practicable, that standard would, as knowledge is acquired on the subject and experience, necessarily have to be raised, would it not ?—Well, it follows logically that it ought to be and that it would be.

29317. And I can quite see that from the point of view of the manufacturer it would be difficult to get the manufacturer to carry out at once such works as would bring about a high-class standard, but it might be more practicable, would it not, to get him to carry out such works as would bring about a provisional inferior standard ? He would be encouraged to carry out what is immediately practicable, and probably would carry it out if he were given an assurance that that would satisfy the supervising authority for a given term of years ?—Well, that would become the standard, you see.

29318. But that would be necessarily a provisional standard ?—Just so, but still for the time being it would be the standard. I do not think it would work to establish a standard to be aimed at as the standard, and then let it be a question to be determined by a Rivers Board or a local authority, as to whether what a trader had done, getting as near to it as he could, with his then experience and his then powers, and if they were of opinion that he had not got sufficiently near, that they were to be at liberty to prosecute him, he had better by far come to the Central Authority.

29319. But this is the point I was wanting to get at, that you have pointed out that there is an inconvenience at the present time in a manufacturer being asked to carry out certain works and a very short time after he has carried them out he is told they are insufficient, and there is no sort of finality in what is asked of him ?—Yes.

29320. And it occurred to me that your own suggestion — and it is your own suggestion—that he should be given an assurance that what he has done shall suffice for a fixed number of years, would be a very useful one ?—I think it would ; but as to what it should be after that fixed number of years should be the subject for inquiry.

29321. Oh, no doubt.—Perhaps I misunderstood your question. I rather gathered that you meant this, to fix a standard to-day which would be one that you are not expecting a trader to immediately attain, but one that he must look forward to having to attain in some years to come, and leaving it at the discretion of a third party as to whether he was making sufficient progress towards attaining that high standard. I do not think that would work at all.

29322. Those are the two ways in which it seemed to me that the thing could be done ; first this way, to have a high standard and say : "We do not expect you to reach this at once, but if you will go so far we will not call upon you to do anything for a given number of years, say seven years" ?—I think you had better by far fix a standard that can be reasonably attained now and let that be the standard, and if a trader attains to that he knows he is safe, he knows he can make pieces and not go to law.

29323. You think there should be a term of years fixed ?—A fixed term of years—well, there might be, but it should not be too often. There has been a lot of waste of money both in dealing with domestic sewage and in dealing with trade waters through not having the experience at the outset and having to alter their plant after, and that as far as possible wants avoiding.

29324. This is not a suggestion of my own, it is a suggestion of yours. You say : "Standards should not be placed too high in the first instance, with power to raise or lower the standards over terms of years, but it it desirable that this position should not arise at periods oftener than seven to ten years" ?—That is my view.

29325. It seemed to me rather a useful suggestion, that if all the manufacturers could be brought up to a provisional standard, and if they could be assured that if they carry out works to bring them up to that provisional standard, that would be considered satisfactory for a given period, but with the understanding that after that period had expired, in consequence of the fresh knowledge that meanwhile had been acquired, they would probably be called upon to carry out works to bring them to a higher point ?—First of all, I agree, and all the traders feel, that it is desirable that a standard should be fixed, but that it is most important that that standard should be one that can reasonably be attained now. They also do not object to the principle that when experience has sufficiently advanced, and say a Commission like yours is satisfied that there are ways and means at a reasonable cost, of lifting it to a higher point they quite agree that that should be done, but it ought not to occur too often. That is my point—it ought not to occur too often ; it ought to be over fairly substantial periods. The way to fix a period would be to consider first of all what is the life of a plant, how much of the life of the plant would in itself be gone over that time, and so on ; these are the considerations, but seven or ten years, I think, is quite often enough to disturb a standard.

29326. I think you wanted to say something on this point, Mr. Mills ? — (*Mr. Mills.*) I defer to the Commission ; I do not want to intervene in Mr. Hanson's examination ; I shall be pleased to say something afterwards.

29327. I was not proposing to deal separately with you gentlemen, but if there is any point which one of you wish to answer rather than another, it might be convenient.—Upon this suggestion that you should have a higher standard than the Rivers Board would expect them to attain at present, the difficulty would be this, it the suggestions of the Association are carried out the duties of the Rivers Board would be a prosecutor's duty. That is to say, you have a certain standard ; if a manufacturer fails to attain that standard the Rivers Board would have a right and it would be their duty to prosecute him for the penalty for the non-observance of the standard, but if you fix your standard at such a height that you do not expect it to be attained for the time being, then in all probability a difference would arise between a manufacturer on the one hand and the Rivers Board on the other, and the Rivers Board would be in a position to obtain a fine, a penalty against a manufacturer, by merely proving that his effluent did not come up to the standard : and although it might be intended at the outset, as you suggest, that that standard should not be attained, yet the manufacturer would be absolutely in the hands of the Rivers Board, and they would be able to get a penalty against him by reason of his not attaining it.

29328. Then you agree with Mr. Hanson that it would be more prudent to fix first of all a standard which is immediately attainable ?—I do, certainly ; I think it would be a fatal error to fix a standard which it was not intended to observe and yet for the non-observance of which the manufacturer would be liable to be fined.

29329. And leave it to the future to raise the standard, if it is possible, practically, to do so ?—Certainly, perfectly willing.

29330. Then do you think that Mr. Hanson's suggestion of having a fixed term of years within which the manufacturer should not be called upon to do anything further beyond what is necessary to bring him up to the provisional standard is a good suggestion ?—Certainly, I think it is an admirable suggestion, and one which would commend itself to anyone who has thought about the subject. Fixing standards is a very important matter, and would require a good deal of inquiry either by the central authority or by some one else, and the very fact of changing that standard, especially to increase it, would in all probability involve a considerable expenditure at the hands of every individual manufacturer, therefore I should have thought ten years was a very reasonable period to fix. (*Mr. Hanson.*) I should like Mr. Sykes to give you his opinion on this point, before we pass from it. (*Mr. Sykes.*) Well, Sir, I think Mr. Hanson and Mr. Mills have fairly well expressed my opinion, but I would put it in this way, that if you fixed the standard as Mr.

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Hanson says low enough to be adhered to by all manufacturers, then at the end of the period that you fix, that is the seven or the ten years, it would be necessary to make an inquiry before you raised that standard to see how far science had progressed and what was possible of each manufacturer, and a thing of that sort could not possibly be left in the discretion of a prosecuting authority, to say whether or not a man had complied with what he was told would satisfy, but which was not the standard. It would be an impossible position to say to the manufacturer: "Now, if you do this, you will not be prosecuted, but the standard is so and so; I know it is much too high, but if you will only do this you will not be prosecuted." As Mr. Mills puts it, then we should be entirely at the mercy of the Rivers Board.

29331. Then you also are in favour of fixing a provisional standard?—(*Mr. Sykes.*) A provisional standard and inquiry as to what progress is being made at the end of seven or ten years, ten years for preference; and then an intelligible higher standard, one that can then be attained as well as the provisional one to be attained when it starts.

29332. You think considerable improvement would be brought about in the rivers if all the manufacturers could be brought up to an immediately practicable standard?—I am sure. You know, Sir, that there are always manufacturers, however much you were to press them, who would lag behind, but if there is a standard they are bound to come to they will all come to that, and they will come to it immediately if it is a practicable one.

29333. You said, after a certain period of time, an inquiry should be made; I take it that you mean by the central authority?—By the central authority, of course.

29334. And that they could state whether in view of the experience gained a higher standard is practicable?—Certainly, and in all probability, as Mr. Hanson said just now, that higher standard could be attained without any more cost to the manufacturer on account of the increased knowledge.

29335. I would like to ask Mr. Hanson what sort of standard would be immediately practicable in these trades. I believe in Lancashire the Mersey and Irwell Board are provisionally satisfied with a standard that there shall be not more than three grains per gallon of suspended matter in the effluent, that the effluent should be neutralised and shall not contain putrefactive matter?—(*Mr. Hanson.*) Well, I should much prefer to leave that part of the question until we know exactly what we have been able to attain and what it has cost to attain it. I should much prefer that, the question in its entirety.

29336. You cannot express an opinion to-day?—I should prefer not.

29337. As to whether a provisional standard of that kind would be practicable?—I should prefer to leave that question over entirely. In order to arrive at any standard a certain investigation must take place. It is only since we received an invitation to come to the Commission, with what information we had, that we have turned our attention practically to ascertaining what can be done at reasonable cost. We are spending a great deal of money, we have two chemists employed on this part of the question in order to find out what we have been able to attain up to now and what it has cost us to attain it, and before giving you an opinion I should prefer to discuss this subject with the Executive Committee, all practical men, when they have the information before them.

29338. It would be of great service to this Commission, in their consideration of a possible standard, to have the opinion of your Association on this point, if not to-day, at as early a period as possible.—It is with that object that we are moving now to get what information has been obtained by the expenditure of money on the experiment amongst the traders. We think it is our duty to give you the benefit of that information.

29339. In the works that you visited in Lancashire you probably saw many instances where a standard of that kind had been reached, the limitation of suspended matter and a neutralisation of the effluent?—Oh yes. As to what degree? (*Mr. Sykes.*) Might I ask on this point whether the standard you are quoting for Lancashire applies at all to discoloration?

29340. Not discoloration; I did not mention discoloration.—You did not. I wanted to know whether you had omitted it, or whether there was any reference to it in the standard they had established.

29341. I do not know that they had established a standard at all; Mr. Tatton perhaps will tell me; I do not think they have established a standard, but provisionally I understand they have passed effluents which have a limitation of suspended matter to three grains per gallon and passed the test of being neutral?—Yes, but no reference to discoloration.

29342. No. Of course, we are perfectly aware that it is very difficult to absolutely remove discoloration in connection with the dye-waters, though considerable progress has been made in that direction.

29343. (*Mr. Tatton.*) No, they have no standard for discoloration in the Mersey and Irwell.—(*Mr. Hanson.*) I am not aware, Mr. Tatton, of any standard at all.

29344. Well, it is not a standard, there is no legal standard, but they have a rough limit of impurity?—Yes.

29345. (*Colonel Harding.*) Perhaps Mr. Tatton would be good enough later on to deal with that point, to mention to these gentlemen what has satisfied the Mersey and Irwell Rivers Board, and how far it has been possible for manufacturers, as a whole, to reach the point that has satisfied them.

29346. (*Mr. Tatton.*) Yes.

29347. (*Colonel Harding.*) Now, in regard to the future, and the alterations of the law, there are one or two points which you have mentioned in your several printed statements which may be just worth referring to. In regard to new works, I gather that some objection was raised by your Association to what was proposed by the officials of the West Riding Rivers Board, when they gave evidence before us?—That was so.

29348. And what do you think, Mr. Hanson, should be the proper course to be taken when it is proposed to establish new works? Should the local authority or the Rivers Board inform the person who is about to establish new works that purification of any trade effluents he would produce would be required and that he must, in laying out his works, take care to make provision for possible purification?—I think, on that point, the procedure that commends itself to me would be this, that either the Rivers Board or the local authority, whichever you like—local authority for the moment, I should say, because the plans of new works would have to be submitted to a local authority—when those plans were deposited it might be made the duty of a local authority to call attention to the Act of Parliament dealing with the pollution of rivers, which they must keep in mind in constructing their works; but as to what sort of a plant they put down, or whether they put down a plant at all or not, I think should be left entirely outside their authority and outside the authority of a Rivers Board. I think the work of a Rivers Board should not commence at all until there is pollution.

29349. You think that the manufacturer may be considered to be sufficiently aware that works of purification will be required?—I think he should, just exactly as a man who wants to build a house knows that he will have to provide proper sanitary arrangements for it. (*Mr. Sykes.*) In connection with that, I may say, Sir, that I was at the sale of a mill the other day, and a large point was made by the auctioneer of the fact that the late proprietor had put down works which had satisfied the authorities, and that that would be a point that the purchaser would not have to consider, so that you see it is getting now into a public matter. It was openly stated in the sale by auction that the late proprietor had put down works which had satisfied the authorities, and that the new man would not have to spend any money on that line. It is now as public as that, and will no doubt come out at every sale in the same way.

29350. You do not think it is necessary when a new manufactory is about to be established that anybody should call attention to what would be necessary until

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pollution arises ?—Well, not so far as the Rivers Board is concerned; but so far as the local authority is concerned, no doubt when the plans are considered that question would often arise. But, still, it would have to be left to the manufacturer to make such provision as he thought proper. If he did not make sufficient provision he would be liable to prosecution.

29351. (*Mr. Tatton.*) Would you allow him to run his waste away for the time ?—I would not allow him any privilege at all. The moment he does not comply with the law he is open to prosecution.

29352. You would not close his works, would you ? It would take some considerable time for the law to be put in operation to remove this matter from the stream ?—Yes, but if the man does not remove it then he is prosecuted. He must make his provision to begin with. If he does not make his provision, and necessary provision, he is liable to prosecution, when he turns out an effluent which does not satisfy the requirements of the law.

29353. But in the meantime the effluent would go into the stream ?—No. (*Mr. Mills.*) You will find the suggestion of our procedure is this, that where the Rivers Board allege that the man is not observing a standard, whether from the imperfection or the inefficiency of his works or there being no works at all, they must give him a two months' notice, calling his attention to it, and then if he does not observe the standard, if he goes on polluting, after the expiration of the notice, unless he can get the Board to extend the time, he will be liable to a prosecution and be penalised for not observing the standard. There is no man in the West Riding who would ever dream of carrying on a manufacturing operation without knowing what the law is as regards pollution.

29354. In a similar instance which Mr. Hanson gave us of a householder, you do not let him run his drains into the street for a couple of months ?—The same as you give notice under the existing Acts. Under the Act of 1894 I think it is, you have to give him a two months' notice before you can take any proceedings, you must also give a two months' notice to the manufacturer here before you take proceedings, and if he contravenes the law, unless the Rivers Board are good enough to give him an extension to comply, as they generally do, he would be subject to prosecution and he must pay the penalty.

29355. But do you not think that he knows—when he goes to his works he will know well enough that there will be pollution from these works, and it is his duty to have his purification plant ready from the time he starts his first dye vat, is it not ?—Before he is prosecuted, as I say, he must have two months' notice. If he does not then cease to pollute, the Rivers Board are in a position to prosecute him for not observing the standard. (*Mr. Sykes.*) I quite understand the purpose of your question, but you see, put it to practice ; what man knowing the law—because they all know the law, and are bound to know the law before they build works—what man will put down new works without full provision for this in the future, what man will be bold enough ? His whole place would be disturbed if he made his arrangements independently of this. You have an idea, but most people have no idea of the disturbance of works that has been caused by these requirements. One of my old friends has had to take all his machinery out of the bottom of the mill and make his provision in the bottom of the mill and build elsewhere for the machinery. These kinds of disturbances no sensible man would subject himself to.

29356. No, that is quite right, as regard disturbance in the mill, but, on the other hand, he very often does not provide the purification tanks ?—Has not done in the past.

29357. Until the very last thing, perhaps not till he started his works. I have known cases of that. Of course, the drains are all laid ?—I quite understand the force of the question, but if you put it to practical test there is no common-sense man, and as a rule they are common-sense men who build works of that kind, would dream of building works without complying with the law, so that the two months would only be a formality.

29358. Well, he complies with the law as regards the drains in his works, but not with regard to purification works ?—As I say, that is in the past ; in the past nobody has provided. (*Mr. Mills.*) The two months' notice is not intended so much for a new manufacturer building new works, because, as Mr. Sykes observed, he would cover at the outset. It is to cover the cases where a manufacturer's works exist at present, where there is no provision for purification, That the man, before he is prosecuted, should have a notice warning him that he will be prosecuted unless he complies with the law. It is the same in that respect as the procedure under the Act of 1894.

29359. (*Colonel Harding.*) The only thing that strikes one is that the person who is putting down new works is in a different position to the person having old works, where possibly no provision is made for dealing with the effluent, and where it can only be dealt with at very great inconvenience, but in the case of new works, where a man is laying out new works, where he is informed at the first that he will have to provide purification works it will be prudent of him in the first instance in laying out these works to provide for them, but you think it is not necessary that special notice should be served upon him that these things will be required, that the general knowledge of the district informs him that this must be done ?—Yes.

29360. Do you see any objection to his being informed ?—No ; but the duty of giving notice should be imposed upon the local authority.

29361. There is no objection to it ?—Not the slightest. (*Mr. Sykes.*) Oh no.

29362. It is a formal notice which cannot do any harm and which will be very useful ?—(*Mr. Mills.*) I would suggest if that were done that it should go beyond that, that inasmuch as there would be a standard, that along with that notice there should be a copy of the standard which he had to observe in his particular trade served upon him.

29363. And your Association sees no objection to a notice being given to a person who is about to start a trade in this district, that a certain purification of his effluent would be required, and that he must make provision at once for it ?—(*Mr. Sykes.*) No, none. (*Mr. Hanson.*) I quite agree with that, but I should like to add that the important point of the difference between the position we have to-day and that which we had when the West Riding Rivers Board, were proposing to promote a Bill, is this, that they themselves were to require that plans of works should be submitted for their approval.

29364. That is another matter altogether.—Yes, presumably, it had reference purely to pollution, although we thought it went a good deal further than that point. The great point is, so far as Rivers Boards and traders are concerned, that they should not be brought into conflict at all at this early stage. Give a notice to a trader, but let it go through the local authority who has to approve the plans of the buildings ; and such a notice as that will come very properly from them, with, as Mr. Mills says, a copy of the standard which he has to comply with. (*Mr. Mills.*) Return the plans, and let a copy of the notice and the standard be affixed.

29365. I am not suggesting that the plans should be submitted to the Rivers Board for approval, but simply that the Rivers Board should inform a manufacturer laying down new works that he would be required to purify his effluent. It is immaterial to them how he performs it, so long as he reaches the standard.—That would come through the local sanitary authority, not the Rivers Board. (*Mr. Sykes.*) Would it not cover that if, as Mr. Mills suggests, a notice of that kind had to be attached to the plans when they were approved by the local authority ; a copy of the standard and a notice of what the law was ?

29366. You see, the local authority is interested in the cases where effluents are turned into the sewers, and they lay down certain conditions, and it is quite right for them to give the necessary notice in that case, but where effluents are proposed to be turned into streams it seemed to me it would be the duty of the Rivers Board.—(*Mr. Mills.*) A standard applicable to a stream would have been fixed, and each local authority would know what that standard was, and, therefore, there would be no difficulty in returning the plans approved, enclosing a notice with that standard. Why should the Rivers Board have to interfere? It would require the local authority to communicate with the Rivers Board the fact that A B was intending to lay down certain works in a certain position; that is altogether unnecessary.

29367. The main point is not by whom the notice should be given to the new manufacturer, but that it should be given; that is the important point.—There can be no possible objection to that.

29368. In connection with one or two minor points, I should like to refer to your evidence. Some difficulty has been met with in connection with samples, and I see you make a very proper suggestion in regard to samples. You say: "That power should be given to take samples from all streams where more than one trader discharges his liquid through one outfall or drain, and to take proceedings against the offenders jointly or severally." I may take it that your Association recognises the necessity that powers should be given to the supervising authority to take samples?—(*Mr. Sykes.*) We do.

29369. And there are cases where it is very difficult to get samples, where an outfall is underground possibly at some distance from the river, and where it goes into a covered channel which also receives the outfall from several manufactories, and in which it is very difficult to find out from which source the evil arises. Would you think it a good provision in new legislation to compel a manufacturer to make the outfall accessible, if necessary, by means of a manhole?—Well, that is a point we have not really considered. I do not think we know of any cases where difficulty has arisen. I believe that one member of this Commission made an observation at one of the hearings, that a good deal depended on the inspector, and I do not think any inspector has ever made a reasonable demand of that sort which has not been complied with by a manufacturer. I do not know of any friction that has arisen. Of course, it is possible for an inspector to become a little bit too officious and sometimes offensive, and in that case he might raise the ire of the manufacturer, but the disposition on the part of the manufacturer is, I am sure, only to help them. We are desirous of purifying the rivers.

29370. Your Association sees that it is necessary that the outfalls from works should be accessible to the inspectors?—Certainly; we try to make them so. Wherever works are made now, all that is taken into consideration in the construction.

29371. But in certain towns arrangements have been made that the outfall should be accessible at any time to the inspector—those are not Rivers Board inspectors, but local authorities inspectors—by means of manholes. That seems to be a very simple arrangement, so that at any time the local sanitary authorities' inspectors can go down the manhole and take samples of what is then passing?—(*Mr. Hanson.*) There would be difficulties with reference to that. I have a case in my mind now where they cannot get to the point of outlet by means of a manhole without removing machinery.

29372. How can an inspector in that case get a sample?—It is very difficult, but we can tell you how they have taken samples. They have gone to the machine and taken a sample of the trade refuse as it flows from the machine.

29373. Then your Association would not object to any reasonable provision for taking samples?—(*Mr. Mills.*) No. (*Mr. Hanson.*) But it should not necessarily be divided up in this way, that access must be given at the point of discharge. (*Mr. Mills.*) Of course, otherwise one part of the effluent of the manufacturer might be very bad, another part might be moderately good, and a third part perfectly good, and all three mixed together might make an effluent of a very different character from the worst.

29374. The important thing is to get to the outfall?—You must get to the outfall. (*Mr. Hanson.*) There are cases where it is very difficult indeed. Here is a mill; here is a drain coming from it, with a branch drain from the dye-house here. (*Sketching diagram.*) Well, we were prosecuted on a sample taken inside this mill, and it had no reference whatever to the trade refuse which was discharged at the outlet, and we were prosecuted successfully, although we pointed out exactly where it was taken. But there would have been difficulty in getting at the outlet; but between the outlet and the point where the other department joined it there were several places where a sample of the effluent could be taken. It does not want to be tied strictly to the point of outlet, but it wants to be where all the trade refuse from that mill is to get mixed up together. (*Mr. Mills.*) When one says outlet, perhaps Mr. Hanson is right. What I rather meant was that the sample should be taken when they had got clear of the works, so that they were taken midway between the works and the stream, which would represent the quality of the effluent at the point of discharge into the stream.

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29375. The important thing is that the final discharge should be sampled?—(*Mr. Hanson.*) That is it.

29376. And your Association is quite ready to agree to any reasonable proposals for access to it?—That is so.

29377. Something has been said about the use of plants, that when works have been put up they have been carelessly managed, and certain prosecutions have taken place where manufacturers have said: "I have provided this plant, and I have given instructions for the work to be carried out, and if there is failure it is due to the negligence of one of my men, who has had instructions to deal with it properly and has not done so." I see you say: "That in cases of the abuse of purification works the employer should be liable to penalties, power therefore being given to them to bring before the court an actual offender in the same manner as under Sec. 141 of the Factory and Workshops Act"?—(*Mr. Mills.*) There is the same provision in the Alkali Act of 1901, but it is rather shorter. Probably it is a better form than this.

29378. This point therefore is not likely to give rise to any difficulty?—None whatever.

29379. Neither is the point of contractor? Something was said to us in the West Riding Rivers Board that there were difficulties arising where manufacturers contracted with another person to purify the effluent for the purpose of getting out grease?—That is so.

29380. The result was unsatisfactory, and it was difficult to find out who was really to blame, but the manufacturer refused to show the documents which governed the case as between him and the contractor, and so on. I see that that is not likely to cause difficulty, because you say: "That the manufacturer should be liable where he disposes of his liquid refuse to an independent contractor who discharges it into a stream in such a state as to pollute it, unless the manufacturer produces to the Rivers Board a written agreement showing that the contractor has undertaken to deal with the refuse so as not to cause pollution." There is no probability of any difficulty arising on that score?—None whatever.

29381. Your Association is ready to agree to any reasonable proposal to avoid difficulty in regard to that?—That is so.

29382. Now you suggest, I think, Mr. Mills, that in referring to the central authority such reference shall only take place if it is impossible to arrange for an arbitration?—The reason of that suggestion is that, of course, it is much better for the manufacturer and the local authority. I do not think anything of that sort will arise with the Rivers Board. That is merely a question of attaining a standard, but for any question that does arise, if parties can agree upon an arbitrator, so much the better. It is less costly, there is no reason to call in the central authority or anybody else if you can agree upon an arbitrator.

29383. Your idea of proposing an arbitrator I suppose is because at the present moment there is no central authority?—If there is a central authority I should give the parties always the privilege of agreeing upon an arbitrator to settle the dispute in that way. It is much simpler and less costly, without troubling the central authority. If they cannot agree, then of course they go to the central authority.

29384. The only point is that in that case you would get an irregular decision. An arbitrator in one case might give a decision on certain lines, and an arbitrator in another case might not abide by that.—That can

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hardly be, because no two are identical, and the decision of an arbitrator in one particular case could in no sense be regarded as an authority to be applied in any other particular case. No two cases are identical, and, moreover, if a man agrees to his own arbitrator he could hardly complain as to the result. (*Mr. Sykes.*) We got over that point in regard to the Huddersfield Bill by what is stated in my evidence. "A Joint Committee to be appointed, four from the manufacturers and four from the Corporation, for the purpose of arranging details and settling all matters in dispute between both parties." That was discussed at many meetings, and this was how we got over it. We are going to have a permanent committee to settle all disputes in Huddersfield. (*Mr. Mills.*) If you cannot agree to an arbitrator it goes to the Local Government Board. (*Mr. Sykes.*) If we cannot agree to an arbitrator, it goes to the Local Government Board.

29385. And ultimately to the central authority?—And then to the central authority; it would do if there were a central authority. We had many meetings over that, and this was the result.

29386. You only go to the central authority if you cannot agree amongst yourselves, and you look upon the arbitration as a stage of the agreement amongst yourselves?—That is so. (*Mr. Mills.*) And no doubt in the course of carrying out any Act of Parliament there would be men recognised in the district as men having special knowledge of particular trades in whom the manufacturers and the local authorities would have more confidence perhaps than in referring it even to the central authority, by whom it might be referred to an officer of whom they knew nothing.

29387. Well, the last point with which I shall trouble you is this, that I see you expect a great deal from the central authority, and you suggest that the central authority should make experiments and tell the traders what to do, but it occurs to me the first responsibility of finding out what is necessary to be done rests with the manufacturers themselves, and rests much more conveniently perhaps with an Association of Manufacturers. Now, you have here an Association of Manufacturers, including a very large number of persons, and here the Association might be extremely useful to its members in promoting experiments with a view to meeting the undoubtedly very great difficulties which present themselves in the treatment of effluents in this district. Do you suggest that the central authority should carry out certain experiments? And I think the suggestion has been made that pending the appointment of a central authority this Commission might probably spend some time in investigating some of the more difficult of the problems. How far it would be possible for this Commission to undertake work of that kind I am unable at present to say, but if this Commission did undertake anything in the more difficult directions to study these matters, I suppose I may safely take it that your Association would give them every possible assistance?—(*Mr. Hanson*) You may.

29388. Then I suppose you would mean they would provide at one or other of the mills, wherever it might be convenient, a site for small experimental plant, and that the Association as such would be prepared to contribute towards the cost of the experiments?—I do not think the Association would be prepared to contribute towards the cost, nor do I think it would be reasonable to ask them, because after all this is an Association interested in the West Riding of Yorkshire. I take it a general Act, when one is passed, will apply to the whole country, and the proper course seems to be that the central authority in the interests of the whole country should conduct such experiments as are necessary to get rid of difficulties which must arise from time to time; and for all time, as long as this subject is being prosecuted, it will be constantly arising on account of the changes that take place in trades. They should conduct those experiments at their own cost, the cost of the country. The traders—I can speak specially so far as this Association goes—would afford such facilities as are in their power to enable them to deal with questions which arise in their particular trades, and if it were necessary to put down a plant I have no doubt whatever that facilities for putting down a plant would be found where the difficulty or difficulties arose. But I do not think the traders should be expected, I do not think it is reasonable that they should be expected, to incur any expense in finding out things which are for the benefit of the whole community.

29389. I am afraid you must not expect too much from the central authority, or from this Commission. The English plan is that people should in the first instance help themselves, and then they have a right possibly to ask others to assist them?—Then I think that places me in a sound position so far as this view goes. Up till now for the last ten years, without help or aid—I say that after consideration—they have been at their own expense finding a way out of this difficulty, and they have so far got through the initial stages at their own expense, that they are now entitled to be helped by the community.

29390. Those are points about which as yet you have given us no information, but which you promise later?—You will see later. (*Mr. Mills.*) May I suggest another reason why the expense should be borne by the country? A manufacturer at present is carrying on a legalised trade; he is not breaking the law; we presume he is not breaking the law. Why should the conditions be put upon him for observing standards for the benefit of the general country at large?

29391. That is just the very point which I think would be questioned, whether it is not very much more to the interest of the particular trade than the country at large. But I would just call your attention to experiments which this Commission has carried out in connection with distillery refuse. In that case we had to deal with an Association which was very much pressed by the landowners, and which was very anxious to obtain a solution of their difficulty, and they did give us considerable assistance, and they provided the plant which we required for the experiments at their expense and which expense was not very much, but such as it was it was provided by that Association, and this Commission provided the necessary expert supervision during the carrying out of the experiments?—In that case only one experimental plant would be required. In the Colne Valley and other valleys you will have half a dozen or more different trades, dyers and different classes of works. You would require a separate test for every one of those trades.

29392. I think you can scarcely expect that this Commission, whatever the Central Authority may ultimately do, would meanwhile undertake all the details of finding out the way of treating a multitude of effluents. This Commission would probably limit itself to the study of the more difficult problems, and those might not be many?—(*Mr. Hanson.*) That would be so.

29393. Probably that would be a point for further discussion with your Association, when this Commission better apprehends what are the points which it is desirable for it to take up. Therefore I need not press it further, but I thought we might take it that your Association recognise how important it is to find a solution of these difficulties, and would be ready to give us any reasonable assistance, if we undertook to study any particular point?—You have an indication of the broad view which the Association have taken in this matter by their offer to put down a plant in the early days, if the Rivers Board would indicate that which was nearest to what they wanted. (*Mr. Sykes.*) If when the time comes you would put your proposition in a concrete shape, I am sure we should be very pleased to consider it, and do all that we can reasonably be expected to do, to further the investigations you intend to make.

29394. Mr. Hanson, I should just like to ask one very general question, on the question of standards. I presume you would all be of opinion that there should be one and the same standard for each particular trade or industry?—That is so. To that point we have given great consideration, and the traders are all agreed on that point, a standard common to the trade.

29395. Then may I ask you whether you consider there may be great differences in the difficulties that individual traders may have in working up to that standard, owing, for instance, to the extent of their premises, or some such reason as that?—Yes, I do agree there will be considerable differences and difficulties; those difficulties you have to take into consideration in fixing your standard. It wants fixing so that all can attain it at the outset.

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29396. Yes, but suppose there was a particular trader who had extreme difficulties owing to the want of space, or some cause like that, and he could only work up to a very low standard indeed. You would not consider it right, would you, to fix the standard at the lowest point to which the most particularly handicapped trader could work ?—Well, I think if the circumstances of a particular trader were quite exceptional, he should be entitled to appeal to the Central Authority for the standard in his particular case to be modified. In fact, I think there should be a power of application by any trader who feels aggrieved by the standard on account of exceptional circumstances. He should be entitled to appeal to the authority.

29397. (*Mr. Tatton.*) I suppose you would consider the shortness of room—supposing he had very little space round his works—would be a particular circumstance in which he might appeal ?—I think it would, if he could show that financially it was going to affect his trade to a serious extent. If he satisfied the Central Authority of that, he should be entitled to some modification of the position.

29398. Do you think you would have many—you know your works pretty well—exceptions of that kind ; works where they were not able really to put down an efficient plant ?—Well, I do know a group of five mills who to-day are without land.

29399. Five mills ?—I know of a group of five mills. They are all together, and they are without land. It would be a difficulty, but, of course, other traders in the same district have had to move machinery. We have considered it very unfair and a serious interference with trade, but that is what has happened. In another case where they had not land, the very next mill but one, the only land available was at the bed of the river, and the bed was vested in a property owner who thought it was his opportunity to make money ; hence the difficulty, and an unreasonable cost had to be entered upon.

29400. And how would you propose to deal with a case like that ; this one you have instanced of five mills altogether ?—It is very difficult to say. I quite agree it will take a good deal of consideration to tell what is obtainable, and a great deal would depend on the standard ; the fixing of the standard.

29401. It is not fair to other traders to let them turn the waste into the river, is it ?—I think circumstances should be exceptional where they are entitled to ask the Central Authority to vary the standard so as to meet their difficulties, otherwise it would tend to create——

29402. You would have a great many ?—Yes, otherwise you would. The broad principle wants keeping that a standard should be fixed which should, except in very exceptional circumstances, apply to everyone in the industry.

29403. You have 241 works altogether ?—Yes.

29404. That is in your Association ?—Yes.

29405 Do you suppose that 5 per cent. of those would be unable to comply with the standard ?—I think there would be less than 5 per cent.

29406. And how many now have efficient works put down ; you mentioned eighty-seven ?—We do not quite know what is efficient in the West Riding, but we have eighty-one works that more or less purify. Some we consider are works that we are entitled to be proud of.

29407. How many of those have further purification plants beyond the seak tanks ?—I cannot give that proportion ; I have not taken out those figures, but you shall have that information.

29408. Have you got works in each trade under your Association ?—Yes.

29409. From which you would be able to get standard trades ?—Yes, we have.

29410. You have ?—Yes, more than one in each branch.

29411. In each branch ; I mean all good works ?—Yes, all good works.

29412. That you would be proud of ?—An average works ; more than average good ; the members of this organisation, representing the interests of the woollen and worsted trade in the West Riding. They are the largest concerns.

29413. Supposing the standard implied that the effluent should be neutral, would that cause any difficulty ?—Well, I should much prefer to reserve my view on every point, because the Executive Committee with all the information before them will discuss the matter in detail before they represent their views to you. To-day it would be my own view. We will try and put it into the shape that would be the view of the traders.

29414. You mentioned one works where it was costing 4d. per 1,000 gallons to treat the trade waste. Was that a small or a large works ?—It is a large works.

29415. Were they treating it in order to use the water again ?—They are, yes. They do use it again.

29416. They do use it again ?—Yes, and in that particular case, although it costs 4d., it is not an injustice, because they can use it. But if that was required at other works it would be a great injustice ; it would be a very serious handicap. At that particular works they can use the water again.

29417. I presume they purify it to a very high standard ?—They purify it so that they buy less water at 6d. That is what they do, but to attain that at other works, where they have not to buy water at 6d., of course would be a serious handicap.

29418. As to standards, you would have one standard, quite irrespective of the class of the river into which the effluent was discharged ?—Certainly, I would not regard the river at all. I would regard the trade.

29419. You say your Association has been urging upon the Local Government Board the desirability of introducing a Bill dealing with the question of trade effluents ?—Yes.

29420. On what lines ; had you a definite line ?—Yes, we had definite lines. We adopted the Third Report of this Commission, and we have stated to the Local Government Board that the traders of the West Riding, members of this Association, approve of the principles of the Report. and we are quite willing they should become law.

29421. That is as constituting a Central Authority ?—Yes.

29422. That is what you want especially ?—That is what we want, and not only as constituting a Central Authority, but in the other respects. For instance, the right to be admitted the sewers and so on ; all the other points ; not limited to that one point. (*Mr. Sykes.*) For Corporations and local authorities to deal with effluents after preliminary treatment. That is a principle that we approve. (*Mr. Hanson.*) Yes, but above all that there should be a Central Authority. (*Mr. Mills.*) And standards. (*Mr. Hanson.*) And standards.

29423. Then of course the question arises as to riparian rights ?—(*Mr. Sykes.*) That we cannot deal with ; we do not propose to deal with it. I may say this, that the manufacturers of the West Riding have been a very peaceful lot. There was a case tried in 1862, I remember, and I think there has been one case since, if so it is only one ; I think there was one case arose and was settled out of Court, but in 1862 there was one that was really tried and, of course, each manufacturer knows what his rights are on the subject. (*Mr. Hanson.*) They could not exist. (*Mr. Sykes.*) You see one of the great points is this, that if you put a great amount of acid into the water it interferes with the man below, but if he knows the element that he had got to deal with—there is a great deal of uncertainty then introduced—if he knows the element that he has got to deal with before these acids were introduced, then he can deal with it. There is an uncertainty now. Perhaps one week an establishment has to put down filtration works, then another week another, and the dyer sometimes does not know where he is. He has to test before and he has to test after. You know the difficulties there are in connection with the discharges.

29424. I quite appreciate that ?—The difficulties there are in connection with discharges.

29425. But have you not had those difficulties with the old seak tank ; was not the effluent from the old seak tanks at times acid ?—Yes, but there have been none to talk about for the last twenty-five years. (*Mr. Hanson.*) They did not pay. (*Mr. Sykes.*) They seemed not to pay and they have not been in use practically.

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29426. (*Sir William Power.*) In your evidence, you speak of the Local Acts of Huddersfield and Heckmondwike, and you say: "The principle of these Acts of Parliament, which provided for the admission of trade refuse into public sewers, is approved by the traders, and has also been approved by the Committees of both Houses of Parliament, it is no doubt well-known to the members of the Commission and should be made to apply to all traders within reach of a public sewer." Are you thinking of legislation to relieve the traders from their obligation to return water to the stream ?—No, no, not at all; it is not proposed that there should be any interference with riparian rights. (*Mr. Sykes.*) We cannot do it. (*Mr. Hanson.*) If a trader takes water out of the stream he is under obligation to the other owners to put that water back and he himself must deal with that difficulty.

29427. You are not proposing to relieve him of that obligation when it is much more convenient to him to go into the local authorities sewer ?—Oh, not at all; he is to have the right of going to the sewer if he can.

29428. And would you relieve him of that difficulty you were speaking of just now when he has no land to make any works ?—Then he must make peace with those who have the land before he can divert.

29429. Under these Acts, has access to sewers solely applied to traders who were not under an obligation to return water to the stream; have any of them under such obligation got any relief for part if not the whole of their liquid refuse ?—Oh, yes; there have been infringements of riparian rights on the Rivers Colne and Holme daily and have been all my life, but the traders wink at it, they have to help each other. If one were to begin litigation on the question of riparian rights it would be a blaze all up the valley, so far all keep peace. The old Association of the Colne Valley Mill Owners' Association, which I refer to in my statement, the Committee of that Association, used to deal with these difficulties and keep them out of litigation. If one said, "Well, he is taking too much, he is affecting the supply of water to my mill," the Committee would settle the matter between the two owners, but kept them out of the Courts, and that preventing solids being put into the river was its principal duty.

29430. Were those generally small works ?—Oh, they are large works, there are none larger than you will find in the Colne Valley, none in England larger. (*Mr. Mills.*) An attempt to carry out the law would stop every manufacturer upon every stream in the West Riding. (*Mr. Hanson.*) Riparian rights are much too dangerous to touch.

29431. On the matter of disputes, has it occurred to you that if you allow disputes to be settled either by an arbitrator or by the Central Authority you will get dis-similar settlements of the same question in the same district, will you not, and the traders would be at a disadvantage if the arbitrator settled a thing in one way and the Central Authority in another and there is danger, I am afraid, of that is there not ?—We do not anticipate that there would be difficulty in that respect.

29432. The arbitrators might be many and the Central Authority would be one. Usually you would get uniform decisions throughout the country from the Central Authority, but you might get very dissimilar decisions on the same subject matter by individual arbitrators ?—I think that by far the best tribunal to deal with the disputes is the Central Authority, but at the same time I feel that in practice it would be well to give the two disputants an opportunity of dealing with their difficulty themselves, that if they have confidence in a third party to let that party deal with it and not bring it as an option.

29433. You think in practice it would not work badly ?—I do not think it would in practice and I do not think after a time, and after a short time, that many disputes would arise. That is the conclusion I have come to. I think if well-defined lines are laid down and the standard, and the rights of the parties clearly defined, disputes will be rare.

29434. And you think that after a time an arbitrator, if he were applied to would be disposed to settle the matter on the lines indicated already by a Central Authority in similar cases ?—I think, having regard to the great experience the Central Authority would have, he would keep himself acquainted with their views and probably decide them on the same lines that they would.

29435. (Chairman) Mr. Whitaker, will you allow your paper to be put into the Minutes of Evdence as it stands ?—(*Mr. Whitaker.*) I think so.

The Bradford Dyers Association, Limited,
39, Well Street, Bradford.
June 11th, 1909.

F. J. Willis, Esq.

Dear Sir,—We are sending you herewith replies to the various queries which, on behalf of the Royal Commission, you put before us on April 21st, 1909.

In doing so we wish to inform you that the Bradford Dyers Association, Limited, was formed in December, 1898, and consists of forty different works in Yorkshire, Lancashire and Scotland, employing at present about 9,000 men.

The authorised share and loan capital is £6,500,000 sterling, and there has been subscribed and paid and the sum of £5,310,227.

The consumption of water at the various works amounts to nearly Three Thousand Million gallons annually. Of this about one-fourth is obtained by pumping from deep wells, one-fourth from town supply, and the remainder from rivers and streams.

As regards the effluent from the various branches, twenty-five of these return their effluent to the rivers and streams amounting to two thousand million gallons, or 65 per cent. of the total consumption. Twelve out of the above mentioned twenty-five branches being under an obligation to return their effluent, amounting to about thirteen hundred million gallons, to the stream from which their supply has been taken.

This Association has spent, at the various works, a sum equal to £10,000 in putting down plant for separating the grease and solid matters from the effluent at the various works.

The above will give you some idea of the enormous volume of trades effluent we have to deal with and the importance to us of fair and reasonable legislation.

We agree with the replies of the West Riding of Yorkshire Mill-Owners' Association of which we are members but in our statement we confine ourselves mainly to the piece-scouring, dyeing and finishing trades.

Yours faithfully,
For The Bradford Dyers' Association, Limited.
(*Signed*) Thorp Whitaker.

Replies to Queries on behalf of the Bradford Dyers' Association, Limited.

Query No. 1.—On what principles should the Commission proceed in framing recommendations as to the extent to which a manufacturer should be required to purify his trade effluents before discharging them into, a river or stream.

Answer.—The guiding principle should be that a trader should not be asked to do more than is reasonably possible, having regard to, the position of the works, and any new restrictions which are not absolutely essential should be avoided.

It seems to meet all reasonable requirements if such regulations provide for the exclusion of:—

(1) Strong soapy liquors which should be acidified and the grease, as far as possible, removed.

(2) Any other chemicals which would be likely to cause a nuisance or be dangerous to health.

(3) Solid matters likely to cause deposit or obstruct the flow of the stream.

Query No. 2.—Should there be fixed standards for various trades, and if so, should the law provide means by which the standard could be raised or lowered according to the character of the stream.

Answer.—We consider the fixing of standards for suspended solids for various trades advisable, such standards to be reasonable and the same for the particular trade or industry. Standards when fixed should be for a term of years at the termination of which period the standard could be modified according to the results generally obtained.

In the piece-dyeing trade suspended solids are usually very light and difficult to separate, being due in a great measure to the reaction of the various effluents on one another and even after settlement a further small precipitation generally takes place in the stream due to oxidation.

Query No. 3.—What methods are available for purifying trade effluents of various sorts within reasonable limits of cost and what is the character or quality of purified effluent produced by such methods.

Answer.—Effluent from dyeing and piece-scouring or finishing works may be divided into:—

(1) Strong soapy waters.
(2) Dye water.
(3) Washing off water.

Of these the soapy waters are the worst.

This is now generally collected separately where possible in tanks, acidified, the fatty magma separated and treated for the recovery of the fatty acids.

The weak acid effluent, which as distinct from wool scouring, contains no wool fat or offensive organic matters, is then mixed with the total effluent.

The dye waters and washing off waters may be allowed to mix together or in certain cases may be separated, the comparatively clean washing off waters being used over again.

Settling tanks are used for the separating of flocculent matter and solids, and the coloured liquid run into the stream.

Discolouration is not considered objectionable if other impurities are taken out. Removal of all colouration is impossible to attain owing to the difficulty of precipitating many colouring matters now in use.

Query No. 4.—Whether there are any cases in which manufacturers experience difficulty in satisfactorily purifying or disposing of trade effluents.

Answer.—We do not consider a dyers or piece scouring effluent apart from the great volume, difficult to treat.

The great volume of effluent necessitates correspondingly large settling tanks if solids are to be taken out, space for which is difficult to obtain in many works situated in towns.

As regards colouring matter in solution this is innocuous, and should be disregarded.

Some of the colours in use may be precipitated by means of lime or alumina, but this treatment may render the use of such water by traders lower down the stream very much more objectionable than using the discoloured water untreated.

Query No. 5.—Whether any alterations are desirable to the law in regard to trade effluents and manufacturing pollution generally.

Answer.—In any new legislation as regards local authorities the basis should be that of the recommendations in the Third Report of the Royal Commission.

Central Authority.

The Central Authority should be supreme and their decisions final, always providing that such Central Authority has among its members experienced men, engineers and chemists who thoroughly understand this question of trades effluents and the difficulties attached to dealing with same, so that traders can appeal to them and have confidence in their judgments.

Rivers Boards.

The duties of the Rivers Boards in the proposed new Act should be administrative, and if definite standards for trades effluents are adopted as against the indefinite character in this respect of the present Acts, their suggestions and experience would doubtless, on this account, be more serviceable to traders in future than has been in the past.

From a traders point of view, we consider the composition of Rivers Boards would be much improved by the inclusion of traders directly represented or co-opted, or others experienced in these matters nominated by a body of traders or by the Chambers of Commerce in any particular manufacturing centre.

In our opinion the complaints of such a joint Board would be more favourably received than from Rivers Boards constituted as at present.

Weirs or Bends.

Powers should be given to Rivers Boards to do away, as far as possible, with unused or unnecessary Weirs and bends in the rivers, and where necessary put in training wall to increase the flow of the river, equitable compensation to owners to be allowed.

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The Erection of New Works.

In the interest of capital trade generally, and of new trade processes in particular, it is not advisable that the power of vetoing the erection of new works on a stream should be vested in the Rivers Boards.

29436. (*Colonel Harding.*) Mr. Whitaker, you come to us as representing the Bradford Dyers' Association?—(*Mr. Whitaker.*) Yes.

29437. Your Association is evidently one of great importance because I see it includes forty different works in Yorkshire, Lancashire, and Scotland?—That is so.

29438. The statement that you put before us is one probably that you would allow us to print in our Minutes, therefore I need not go in detail through it, but merely ask you a question or two with reference to it?—Yes.

29439. Of those forty works, twenty-five deliver their effluent to the streams?—Yes.

29440. And you mention to us that the total volume which they turn out is two thousand million gallons annually?—Yes.

29441. The figure is quite an alarming one, but when you divide it by twenty-five to get the volume turned out by one, and again by 365 to get the volume turned out daily, the figure is not one that need alarm us very much, but it is evident that in connection with those dye works, the volume is quite considerable which has to be dealt with. Works have been carried out by the Dyers' Association, at I believe, the greater part of these works, have they not?—The greater part, yes.

29442. Now we should be interested to know generally what the processes are that you have carried out and the nature of the results that you have been able to obtain?—Well, of course, they cover both cotton and woollen branches to begin with. In the cotton branches, chiefly subsiding tanks and filter beds have been adopted. In the woollen branches we have the scouring and strong soapy waters which are cracked with acid and the fatty magma taken away, and the effluent from that, which of course, is acid, mixed with the general effluent from the works and run away. In one works particularly we put down plant—I am speaking now of Bradford where I think some of you gentlemen saw the plant—both to soften the water, that is to say the waste water, and also to filter the effluent generally from suspended solids. You saw the result. I think it was satisfactory. Dr. Wilson says it is satisfactory. The cost, so far as we have gone, is a little difficult to estimate, but I think in regard to these matters perhaps it is as well I should not give you details in the meantime, but go into it and get them ready at the same period as you are going to have the others in October. Probably that would be the better plan. I can give you roughly some idea.

29443. I think it would be sufficient meanwhile for us to go on, that they are within practical limits, that they have not ruined the industry?—Well, of course, as far as that is concerned I cannot say they do. It depends entirely upon how far you have to go.

29444. You have found it reasonably practicable to carry out certain works. Now what kind of results have you obtained. Are you able to limit the suspended matter in your effluent say to anything like 3 grains per gallon?—No, I think it is too low.

29445. How near do you approach to that?—Well, at the works at Bowling, that Dr. Wilson went to, I think he gives it himself as about 10 or 11.

29446. 10 grains per gallon?—No, 10 parts per 100,000 which is rather more than 10 grains per gallon.

29447. That is as far as you have been able to get?—Yes, that is as far as we have been able to get.

29448. Are you able to go further?—I do not think it is necessary. And there is another thing which you want to bear in mind, that in most of these works, even when you have got down to 10 grains per gallon and you filter it if you like, it is perfectly clear, as you well know, if it runs along a stream and becomes oxidised, due to the oxidation of the air, you get a further precipitate and this is a filter which Dr. Wilson says is perfect, but if the clear effluent from the filter is shaken up in contact with air and allowed to stand a few hours a further precipitate falls down. It is a very light flocculent matter greatly due to the action of one effluent or one

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part of the works effluent, on the other by this action you get a precipitate which may or may not come down in the time you allow it to settle or even after it has passed the filter plant. It is no detriment that I can see in quantity or in quality, it is purely colouring matter innocuous.

29449. I am not expressing any opinion as to whether that is sufficient or not, I am merely obtaining information from you as to how far you have been able to get in your treatment, and you tell me you have been able to bring the suspended matter down to 10 parts per 100,000?—That is on a typical plant with something like £3,000 or £4,000 spent on it.

29450. Obviously you cannot expect to accomplish these results without spending some money upon it?—No, but when you have forty different works and £4,000 spent on each it is rather a different matter.

29451. Now what kind of result have you been able to obtain with regard to the effluent being neutral?—They are mostly neutral.

29452. You have been able to obtain a neutral effluent?—I mean, generally speaking, the effluent from a dye works is neutral.

29453. At your Bowling Dye Works I think you have Bell's filters, have you not?—Yes.

29454. Have they proved to be efficient?—Well, they are efficient as far as they go. They do not go far enough, because I tell you, afterwards you get a further precipitation.

29455. A secondary precipitation?—A secondary precipitation.

29456. At which works do you consider the best results have been obtained?—Well, I should say from ——

29457. Bowling Dye Works?—I do.

29458. I am at some disadvantage in not having been myself able to be with the Commission on the occasion of their recent visit?—I see; I thought you were there.

29459. But at some of your works, at some of your large works in Bradford, you have no treatment at all?—That is so. There is a group of four works there which have no room whatever; the effluent goes straight into the stream.

29460. In that case it is the absence of room that prevents you having any treatment?—It is at present; there is no room for it.

29461. What would be the issue out of that difficulty?—Well, I take it there would be ways and means. When you bring in a Bill they will have to make some arrangement for a difficulty of that kind. As has been said before this morning, surely there are exceptions to every rule. If it has to be done it will have to be done as far as reasonably possible.

29462. May I ask you if you have visited any of the places in Lancashire where considerable works have been carried out for the purification of dye waters?—I have visited our own works there. We have works in Lancashire as well as Yorkshire, and I have seen their plant for doing it. Personally, I do not think the suspended solids are any less there than they are with us.

29463. Have you seen the works of Mr. Clay at Cheadle?—No, I have not.

29464. Something was said to us, by one of the manufacturers that he had found an advantage in treating his waste waters, because it reduced negligent waste in his works, that he was able to detect waste that ought not to occur, and which was to his serious disadvantage. I suppose that would be generally applicable to all manufacturers, that where you turn effluents into the river a manufacturer is not able to have the same control that he has if those effluents are turned say, into gathering tanks where there is settlement. He is able to detect any waste of materials?—Well, I should say that applied perhaps more to indigo than anything else; I do not know, I cannot quite gather what you mean, because in that case I am afraid it does not help us in the slightest; our effluents are of all colours mixed together.

29465. Do you not think there is a good deal of avoidable waste of materials which is allowed to go into streams where there are no works?—I do not think so. I am speaking now of the Bradford trade, the dress trade, I do not think so.

29466. I think you will probably find, as some have found, that the provision of works enables them more fully to control avoidable waste in the works?—Well, it is a very difficult matter to precipitate some colouring matters as well as to exhaust them from the baths. There is great difference in them; some colours will exhaust from the bath absolutely, others will not be absorbed, you cannot exhaust them, you can only go on a certain time and you are obliged to run the unused colouring matter away. Of course, there again, the waste colouring matters are innocuous. They are organic aniline colours, the bulk of them at any rate.

29467. Not having had the opportunity of visiting those works, I will not ask you any further questions myself, but I would refer you to the evidence which you have heard just now from the Mill-Owners' Association; I think you are a member of it?—Yes.

29468. You have heard the questions that have been asked and the answers that have been received; is there any point in regard to those that you would like to call our attention to, I do not want to go over the same ground again?—No, I think they have pretty well exhausted the subject so far as that is concerned, I do not see that I can add anything. I certainly agree to what they have said in their answers, in that respect generally.

29469. (*Chairman.*) Is there anything you would like to add in consequence of what you have heard this morning?—There is one point that I have in my evidence here, that is with regard to the composition of the Rivers Boards. We think that Rivers Boards, as constituted at present, might be improved. They are composed of gentlemen from cities and also gentlemen from the country. The country predominate as a rule, and we think that men, traders if you like, or representative men co-opted by Chambers of Commerce might be added to such Rivers Boards with advantage.

29470. That you have mentioned in your Memorandum?—That is so, still I wish to emphasise the matter.

29471. (*Mr. Tatton.*) Shall we have more information in October, not only from your works, but from other works in the Bradford Dyers' Association?—If you wish it, certainly.

29472. You are having experiments made as regards the effluent?—We will have. We have data, of course, up to a certain point now, but if you can indicate anything further that you would like, or give us lines on which you would like us to work, we should be very willing to work on them.

29473. We want to know what is the best average effluent or the best effluent that you can produce, really that is the chief idea?—I see. Well, of course, the works vary. The best effluent from one works, say a print works if you like, or a bleach works, is a different thing entirely from that from a dye works in the Bradford district. The one is woollen, and the other is cotton; the one has a lot of fillings in and the other has not.

29474. I am referring to work under your Association?—They are under our Association. We have works as far as Wigan. We have one in Scotland, we have the rest in Lancashire and the West Riding of Yorkshire.

29475. Are they getting better results do you think in some of these works in Lancashire than in Yorkshire?—I do not think so. Mind you, they have a different effluent to deal with, an effluent which contains far more what I may term starchy matters, fillings generally, than we have.

29476. You are speaking of print works now?—No, I mean dye works, but the class of work there is different. Even in the cotton trade it is a lower class of work which requires, as you know, more filling than the higher class cotton or the woollen requires in Yorkshire.

29477. Would you have to put them under a lower standard or would you have to have a variable standard for works of this kind?—You are speaking now of the suspended solids.

29478. Yes?—Well, I do not know. You would have to put them under their own standard, that is to say, the cotton dye works as well as the woollen dye works.

29479. (*Sir William Ramsay.*) But what about mixed pieces?—Mixed?

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29480. Yes ?—Cotton and woollen.

29481. Yes ?—Well, in many cases the cotton is already dyed when we get it, and even in those cases the amount of filling required is not the same as in a low class cotton. They are usually very high-class goods. Take Mohair Sicilians and other Ladies' dress goods, they are high class; there is no filling there in the cotton or the woollen, and yet it is a mixed cotton and woollen; it is a cotton warp usually already dyed beforehand.

29482. But would it not make it very difficult to lay down standards for each class of material ?—I do not say for each class of material, but for each class of work or trade.

29483. That will have to be adjudicated upon by the Central Authority in point of fact ?—Exactly; they will have all the information I take it.

29484. (*Mr. Tatton.*) Do you use precipitants when you are treating your trade waste; do you precipitate in the first instance ?—In Lancashire, yes.

29485. I have not been to your works at Bradford ?—Have you been to the works in Lancashire, at Wigan for instance.

29486. No, I have not been to them ?—Any in the Manchester district ?

29487. Yes ?—Well, we use alumina ferric chiefly.

29488. Do you use that at Bradford ?—Yes, we use that and lime or alumina alone.

29489. Do you filter after precipitating ?—Settle.

29490. You just settle, but you do not pass them through a cinder filter ?—No, in this case we do not.

29491. Do you think you could get below 10 grains, you spoke of 10 grains to the gallon ?—10 grains is the effluent from that particular works where the effluent is about 1,000,000 a day.

29492. In spite of precipitation ?—There is no precipitation in that case.

29493. You have no precipitation ?—No, I am not speaking after precipitation. There is a settlement reservoir equal to 2,000,000 gallons.

29494. For 1,000,000 discharge per day ?—Yes.

29495. It holds two days supply ?—Yes.

29496. Do you not think you could improve the effluent by precipitation ?—I do not think it is necessary; I do not think 10 grains is too high by any means; I think it is too low, much lower than most works are sending.

29497. Well, we get better than that; we have seen some works lately that do still better work ?—May I ask where.

29498. Well, I could mention Clay's of Cheadle ?—Clay's of Cheadle; well we are always open to learn; they are in the same trade practically as our own in the Lancashire district; have they any special plant.

24999. They have precipitation and filtration, but most of the work is done by precipitation ?—Is it a special plant ?

29500. No, it is not a patent plant, it is ordinary precipitation tanks.—Yes.

29501. Top waters drain off and the sludge taken away.—I see. We have a plant in Lancashire called the Archbutt Deely plant which will get below 10, but that is another £4,000 plant.

29502. (*Sir William Ramsay.*) The only other point which occurs to me to ask Mr. Whitaker is this; is your Association of the various manufacturers being equally treated just now; have some people been proceeded against who are obliged to purify and others have been let alone ?—No; we have notices to proceed against us.

29503. But there are no cases of flagrant injustice where some particular manufacturer has had to pay large sums for expensive plant, while his neighbours in the stream had been left alone ?—Well, you find that in the West Riding generally.

29504. You have not found it ?—Oh, yes.

29505. You have found it ?—Oh, yes; that is to say a man who is going into the sewer, you mean another man has to go into a stream.

29506. I was thinking of two men in the same stream where one has been proceeded against and the other not; you would probably know if there was considerable discontent on the point; it would be sure to have come to your notice I fancy ?—I do not remember at present.

29507. (*Colonel Harding.*) The only cases where there are manufacturers turning waters into the stream, who have not put down plant, are the cases for instance which you have mentioned to us, the four of your own works where there was no room for carrying out works ?—Well, practically that is so; the others have settling tanks for intercepting solids.

29508. There is no case for causing dissatisfaction in the direction Sir William Ramsay has suggested; the Rivers Board I suppose put the same pressure upon all manufacturers ?—Of course, I can hardly say as to that, personally I do not know that we have any particular pressure put upon us more than anyone else.

29509. So that in fact, so far as you know, there is no dissatisfaction arising from that source ?—Well I should almost think that there is a little. The smaller men seem to think that they are more hardly dealt with than the larger. (*Mr. Hanson.*) And the poorer firms than the richer.

29510. Is it that the richer and larger firms are not so ready to fulfil their responsibilities ?—(*Mr. Whitaker.*) I do not know; probably the difficulties are greater. Of course in this case we are speaking now without standards unfortunately. If we had something definite to work up to we should know where we were, we should know what we had to do or to attain, and I think an effort would then be made. At present you may spend any money you wish and you may spend a lot if you take any notice of the Rivers Board as it is constituted and you get no further.

29511. You think the fixing of a standard is essential ? —I think it is essential and the wisest thing that can be done.

29512. (*Sir William Ramsay.*) The standard would have reference to the effluent and not to the river into which the effluent flowed ?—That is so.

29513. (*Sir William Power.*) Well, Gentlemen, the Commission are much indebted to you for the help you have given us to-day and we are also grateful for that which you have promised us in the future.

NINETY-FOURTH DAY.

Monday, 25th October, 1909.

PRESENT:

The Rt. Hon. The Earl of IDDESLEIGH (*Chairman presiding*).
Colonel T. W. HARDING, J.P., D.L.
Sir WILLIAM RAMSAY, K.C.B., F.R.S.
Sir WILLIAM H. POWER, K.C.B., F.R.S.
Mr. T. J. STAFFORD, C.B., F.R.C.S.I.
Mr. R. A. TATTON, M.Inst.C.E.
Mr. F. J. WILLIS (*Secretary*)

ALSO PRESENT:

Dr. A. C. HOUSTON.
Dr. GEORGE McGOWAN.
Mr. C. C. FRYE.
Mr. G. B. KERSHAW.

Mr. T. J. S. ROBERTS, of Messrs. George Roberts & Co., Ltd., Selkirk, called in; and Examined.

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29514. (*Colonel Harding*) (*in the Chair.*) You are Mr. T. J. S. Roberts ?—I am.

29515. And what is the name of your firm ?—George Roberts & Co., Ltd.

29516. And where is it situated ?—Selkirk.

29517. On the banks of what stream ?—The Ettrick.

29518. What is the nature of the business in which your firm is engaged ?—Woollen manufacture, from the beginning to the end, from the raw wool to the finished cloth; Scotch tweeds.

29519. And what are the classes of wools that you use in your manufacture ?—Mostly Colonial wools; a considerable proportion of Scotch cheviot but mostly Colonial; both merino and crossbred.

29520. You do not use any of the long wools that are used in the worsted trade ?—Oh, yes, we buy a lot of them; we compete against the Bradford men for those.

29521. Then may we take it that the refuse waters from your works would be very similar to the refuse waters from the wool washing in the Bradford trade ?—I should think they must be, but I cannot speak from experience.

29522. Do you think they would be as foul ?—They must be I think; we use the same wools.

29523. Now, we ask you upon what principles should the Commission proceed in framing recommendations as to the extent to which a manufacturer should be required to purify his trade effluents before discharging them into a river or stream. What do you say to that ?—This is a difficult question to answer, but in my opinion these effluents should be rendered innocuous to animal life, if that be possible at a reasonable cost so as not to cripple an industry which is giving employment to a large number of people.

29524. Would you explain to us what you mean by animal life. You do not mean that the stream should be kept fit for drinking purposes, do you ?—It ought to be good enough for drinking purposes for animals—cows, and so on.

29525. And you think, when you speak of the stream remaining innocuous to animal life, that cattle might drink it with impunity, and that fish life should be preserved ?—I meant fish life also.

29526. And you suggest to us that that is generally a result which is practicable ?—I think it is. I think we are doing it now.

29527. At your own works ?—At our own works.

29528. Have you in your immediate neighbourhood many other works of a like character ?—The whole district is employed in the same industry—Selkirk, Galashiels, Hawick and Peebles.

29529. What is the condition of the stream on which your works are situated ?—In Selkirk we have a better chance than either Galashiels or Hawick, because we have not so many mills and we have a larger stream. In Galashiels it is very bad, but, as I point out later, Galashiels is now putting down a large sewage scheme.

29530. (*Sir William Power.*) Are there mills above you on your stream ?—None. Hawick also is very bad; the Teviot is disgraceful.

29531. (*Chairman.*) The stream above you, I gather from your answer to Sir William Power, is a pure stream ? —Quite pure.

29532. What is the effect of your discharge upon that stream ?—Our individual discharge ?

29533. Yes ?—Practically nothing.

29534. You say that the appearance of the river below you is as good as above, and that fish thrive as well below as above ?—Below our mills, yes, there are no mills above us; we are farthest up of the lot

29535. Then have you any idea of the relative volume of your discharge and that of the stream at your works ? —Oh, pure guess-work.

29536. But may I take it that the dilution will be very large ?—Very large.

29537. So that your effluent might conceivably be fairly foul, and yet not have an appreciable effect upon the large volume of the stream ?—No; if it came in very foul, it discolours a long way down. For instance, within the last few weeks one of our tanks was not working; there was something required repair, it was out of work, and the discharge from these tanks made the river run thick; some of the sediment had not settled properly to the bottom, and it ran thick. It was discoloured probably for a couple of hundred yards down the lade into which it runs. To avoid that we are just now putting another tank in, so that we may have one off now and again. We scarcely have enough to do it properly, unless they are all in operation.

29538. Then if a discharge takes place in these exceptional circumstances, the effect on the stream is very visible ?—Quite, for discolouration.

29539. It might be convenient if at this stage you would be good enough to explain to the Commission what is the process that you carry out at your works.—We got the idea from a firm in Lancashire, and the whole of the effluents from the different departments are run into one receiving tank. The mixture then is pumped into these tanks above ground.

29540. Forgive me for interrupting you. You have surely a preliminary process of extraction of grease ?—Oh, yes, so far as the wool scouring and the scouring of yarn and pieces is concerned, we have done that more than forty years

29541. Then, first of all, you extract the grease as far as it pays you to do so, and as far as it is convenient to do so ?—Yes, the grease and oil.

29542. The effluents that you are now speaking of, and that you mix with others, are the result after the extraction of the grease ?—From those two departments.

29543. Yes.—The other effluents from the dye works, for instance, and from the milling process, run into this tank. The liquors mentioned above, after the grease and oil have been extracted, are also run into this tank, and everything is run in there so that it is all mixed together.

29544. Yes, we understand now. Proceed, please.—Then it is pumped from there into tanks above ground, so that we can deal with it handily. Lime and copperas are made up in a separate little tank and dissolved. After the large tank has been filled with the effluents the whole thing is well blown up, as we call it, by forcing air into it; it is just like boiling. Then we inject the copperas and lime into the tank, so as to mix it thoroughly, using, of course, such copperas and lime as will settle the sediment, and take the colouring matter out without a superfluity of it, and that was why we got this analysis I gave you. We wanted to be sure ourselves that we were not sending into the river anything deleterious in the shape of lime. This lime and copperas is injected into it, and it is thoroughly boiled up again with air, so as to mix it thoroughly; then it is left alone and it settles, the sediment falling to the bottom. We have a floating discharge which is let down into the top of the tank after settlement, and it runs away the clear liquor, until it gets near to the bottom, and the man has to watch it. When it gets near the sediment he stops it, pulls it up and fills again. When we get too much sediment, it is taken out on to filter beds. It is simply for the purpose of drying it, to enable us to cart it away. Of course, the whole process is one that does not pay us at all.

29545. Before you come to the question of cost, we will just deal with the process itself. You have described the process; had you completed your description ?—I think so.

29546. May I take it that it consists, first of all, of the withdrawal of grease by certain processes, and the mixing of the effluent from that process with other effluents from other parts of the mill ?—That is right.

29547. And treating them in a tank ?—That is right.

29548. With lime and copperas so as to bring about a precipitation of as much of the suspended solids as possible ?—That is right.

29549. And then you flow off the liquid, and that passes into the river ?—Yes.

29550. (*Sir William Ramsay.*) To make that point clear, do you crack your grease before your liquor runs into the tank ? Do you make any effort to recover your grease just now ?—Oh, yes, we have done so for forty years.

29551. And that is done before the liquor is run into the tank ?—Yes.

29552. It is only the sulphuric acid which has already cracked the grease which goes into the tank ?—Yes. And in consequence of that sulphuric acid we require to use much more lime and much more copperas to counteract it in the purification.

29553. (*Mr. Tatton.*) You do not recover the grease from your sludge, from the large tanks at all ?—No.

29554. That is not worth while perhaps ?—No, the difficulty is to get rid of it; we have to take it away and dispose of it in any "toom" we can get for putting it.

29555. Quite so. Are you speaking of trying to avoid any lime going into the river ? Is your effluent generally alkaline or is it acid from this process ?—I have given Colonel Harding an analysis that we got for our own satisfaction, which is much more satisfactory than we anticipated.

29556. (*Sir William Power.*) Does the effluent from these tanks go direct to the stream, or is it passed through any strainer or subjected to any further process ?—No further process.

29557. (*Mr. Stafford.*) What proportions of copperas do you use ?—Each of these tanks that we have has 20,000 gallons capacity, but they are worked at from 16,000 to 17,000. They are not quite full. In the ordinary discharges, besides the wool scourings, we require——I have got the exact figure.

29558. (*Chairman.*) You made no estimate of the amount of lime and copperas per gallon ?—The amount of lime we use for the wool scouring is 40lbs. per tank, and 8lbs. of copperas. I am wrong; the amount of lime used for the wool scouring is 40lbs. and the amount of copperas used is 40lbs.; for the ordinary liquors, 8lbs. each.

29559. (*Mr. Stafford.*) What is the total volume of the discharge ?—Well, we have got 16,000 to 17,000 gallons in each tank; it is——

29560. And how many tanks ?—We have five, and we are putting up another, making six, but that is an extra tank.

29561. The proportion is for each tank ?—For each tank.

29562. Each tank holds 20,000 gallons ?—Yes, but there are only 16,000 to 17,000 gallons in it when working.

29563. (*Mr. Tatton.*) Then how often do you fill each tank per day ?—Ten tanks a day; each tank twice.

29564. Each tank twice ?—Yes.

29565. That is 16,000 multiplied by 10 ?—But, as a matter of fact, we only get about one hour's settlement in each tank; we want to get more. I may say we have all along been anxious to keep the rivers pure, and we have done all we can in every way. I come to that later on. The difficulty the manufacturers have had in the past was that they did not know what to do.

29566. (*Chairman.*) May we take it that the amount of precipitant necessary, according to your experience, has been 40lbs. of lime and 40lbs. of copperas per 16,000 gallons ?—For wool scouring liquor; that is where the acid is.

29567. I thought you said you mixed all these liquors together into a tank ?—Yes, but when we run the water away after treating the wool scouring and the piece scouring to get the grease and the oil out, they are not running constantly, they are running now and again; when we get that liquor in with the other we find that we require this amount of copperas and lime to counteract the acid.

29568. (*Sir William Power.*) Then you apply that before you mix it with the other liquors ?—Oh, no.

29569. Not separately ?—The man knows at once when he sees it what is coming.

29570. Your liquor contains in it sometimes the liquor from the crack and sometimes it does not ?—That is so.

29571. (*Chairman.*) And the attendant, judging from what is flowing, applies the process ?—Not only from what is flowing, but he samples it. He gets it into a clear glass like that (*pointing to water glass on table*), and he sets it up and sees that it settles. If he has not enough into it he will put a little more.

29572. Then what is the total volume of the waste from your mills ?—Well, we have ten of those—about 160,000 to 170,000 gallons a day.

29573. (*Mr. Tatton.*) Can you give us the relative volumes of the grease liquor as compared with the general effluent; that liquor that you treat from the scouring of the wool and the scouring of the pieces—that first treatment ? Do you know what volume that would be ?—I could not give you that; I could find that out for you. I should think it cannot be more than one-fifth or one-sixth of the whole.

29574. Of the whole ?—Yes.

29575. (*Sir William Power.*) When they happen to be mixed in the same tank, do you mean, or in reference to the total bulk ?—The total bulk for the day: I should think it cannot be more than one-sixth.

29576. The effluent, of course, always goes to the main tank; the effluent from the grease ?—After we recover the grease.

29577. Yes ?—Always.

29578. (*Mr. Tatton.*) Yes, that always goes.—Always goes.

29579. Then do you crack the grease with acid ?—The way we do that is this. The process is the same with the piece scouring and the wool scouring. The liquor is pumped into tanks for the purpose, and it is

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blown up in the same way with air; then acid is put in, and it is continued to be blown up so as to mix it thoroughly; then it is allowed to settle, the only difference being that in the wool scouring most of it goes to the bottom because of the soil and earth in it which is heavier than in the piece scouring, and that goes to the top because it is oil. We recover oil from that; in the other we recover grease, which requires to be refined again. There is a good deal of stearin in the grease from the wool scouring; as a matter of fact, there is a great deal of it, the natural grease from the wool. We were getting so much of it at one time that I kept a correct note for months of every pound of soap used in the wool scouring, and we got about five times the amount of grease, magma, from the wool scouring; that is, we got five times the value, so that we were recovering so much of the grease of the wool, natural animal grease, and there is a great deal of stearin in it.

29580. (*Chairman.*) Can you find a ready market for it?—No, we have not. There is only one man buying it; we are afraid he will stop some day.

29581. (*Mr. Tatton.*) Is your effluent clear; do you get a clear effluent from the purifier?—Yes.

29582. There is no suspended matter in it practically?—Well, practically nothing.

29583. Do you filter as a final process?—No, we do not filter at all.

29584. (*Chairman.*) You have had an analysis made of the effluents, which you have just handed to me?—Yes.

29585. But have you only one analysis?—That is all. The date of it is there. It occurred to us that we would like to know what was going out.

29586. This analysis is dated July of this year?—Yes.

29587. Then may we take it that these works are quite new?—We have been doing this for the last five or six years.

29588. You have no previous analysis?—No, none. We never got it so satisfactory. We have always been working at it, trying to get it more satisfactory, and we got it pretty good in the end, and we wanted to see for ourselves what it was like. Messrs. Mather & Platt gave us the idea. It is the same principle that they are using on the railways, I believe, for softening water.

29589. You have tried some experiments in regard to your effluents, to see the effect of it upon fish?—We did not; we asked the analyst to give us the analysis of the effluent, and to test it on fish life, which he did.

29590. With what result?—He says: "The foregoing results show that there are no injurious chemicals present in the water. This is verified by the fact that ordinary fresh water small fish, such as minnow, have lived in the undiluted water for several days." We asked him specially to test it for that.

29591. But I think you said that this was an exceptionally good result?—Oh, no; we had got to that stage; we are doing it now, quite as good as this, and we have been doing so for some time.

29592. Then you suggest to us that that analysis and the experiments with fish represent the usual conditions of the effluent as turned out at your works?—Yes, and you yourselves can test that if you like by sending anyone to see the results; come on a surprise visit at any time, because we want to have the thing going on day by day in the best way we can.

29593. (*Sir William Ramsay.*) Are your effluents coloured as a rule?—Not as a rule.

29594. The dye-stuff is precipitated, I suppose, with the copperas?—It is precipitated. The only discolouration that I personally have seen was a very slight tinge of yellow, which you could only see in volume; you could not see it in a small quantity.

29595. I suppose you do dye your wools various colours?—Various colours.

29596. But the excess of dye stuff is taken out by the wool itself?—Yes.

29597. And anything that goes over is precipitated by the copperas?—Well, we are using practically no chrome nowadays; that used to be one of the worst things. It is now nearly all aniline dye that is used.

29598. And wools take up those aniline dyes very thoroughly?—Very thoroughly.

29599. It colours the vat?—Yes, and after all there is nothing injurious in them.

29600. It does not colour to any appreciable extent?—No, the Diamond Black we use is the worst we have to treat, and from that we get this slight tinge of yellow.

29601. (*Chairman.*) What authority in your neighbourhood supervises the stream for the purpose of preventing pollution?—None.

29602. Does the County Council take any part?—No, the Roxburgh County Council have applied for powers, but there is nothing done.

29603. The works which you have carried out for the treatment of your effluent have not been carried out under the pressure of any authority?—Not at all, but we had a standing example before us in Galashiels a number of years ago. Certain riparian owners proceeded against the manufacturers in Galashiels for pollution, and it was an interminable case in the Court of Session, our principal Court, so much so that the judges in the end said it was interminable, and could not be allowed to go on any further. They appointed an expert to examine things and report what was best to be done, and he reported certain things. I say in the draft I gave you that it cost over £30,000, but I find it cost nearly £37,000, and that money might just as well have been thrown into the sea for all the good that resulted.

29604. You think it would have been better spent in purification works?—Well, they did spend it in purification works. The expert said that certain things had to be done. They all began doing these, but each one at the same time experimenting on his own account. They had been doing that before.

29605. (*Sir William Power.*) You mean, if it had been pooled and administered by a single body it would have been better. If the £30,000 had been pooled instead of all these manufacturers experimenting independently it could have been done by some skilled person?—Yes, quite so, and there should have been some inspector appointed to see that the work was done properly, because, of course, there are always men who will evade spending money if they can do it.

29606. (*Chairman.*) You are aware that in Lancashire and Yorkshire there are Rivers Boards, authorities who have inspectors to do the very work which you suggest should be done in your neighbourhood?—So I understand.

29607. And do we understand that you think there should be for each stream or for each watershed a Rivers Authority, whose business it should be to compel manufacturers to carry out suitable works, and when they are carried out inspect them, so as to see that they are kept in efficient order?—We do think so; so much so that in the Roxburgh County Council I seconded the motion that a Rivers Board should be formed, but it has never been done. One difficulty, of course, they say is that part of one side of the Tweed is for a certain distance in England, the rest of it is in Scotland.

29608. Then you think it would be better to have a Watershed Authority than a County Authority?—Oh, certainly.

29609. (*Sir William Power.*) And you think this Body, so constituted, should experiment as to the best method of dealing with these things?—Before going from it, it should be for a Watershed, not for a County, because there are several counties; Selkirk, Berwick, Roxburgh, Peebles and part of Northumberland are all in the Tweed District.

29610. (*Chairman.*) You would prefer it should be the area of the watershed?—The watershed.

29611. And not the county?—I think so.

29612. (*Sir William Ramsay.*) If there were an area of the Tweed Watershed?—The Ettrick is a tributary of the Tweed; the Gala and the Teviot also, they are all polluted.

29613. (*Sir William Power.*) Were you thinking of any methods of investigating and dealing with trade refuse?—In the past, in the Galashiels case, the difficulty was for the manufacturers to know what to do. We in Selkirk were watching this case very closely, because if we could have been shown a reasonable feasible way of doing it, we were prepared to adopt it, but we never saw anything good come of it. This scheme of ours we got by a mere accident from Messrs. Mather & Platt, the large engineers who put it before us, and it looked as if it might do; we started and tried it, and found it did do; then we added tank after tank until we had got the thing into a proper business shape with just a little accommodation. The difficulty was that the manufacturers did not know what to do, and they were all spending money in experiments. Now it would cost a Central Authority, like some Government Authority, a small sum to experiment with the discharges from each trade, where it is now not known how to deal with them; it would not cost them very much.

29614. (*Chairman.*) You think it is the duty either of the Rivers Board or some Central Authority to make these experiments?—I think it is reasonable.

29615. But are there not manufacturers' Associations which might take up this problem?—We have not got such with us.

29616. You have not in your district?—No.

29617. Do you not think it might be worth while for manufacturers in some great trade, where many are gathered together, to join together, to pay some expert to discover for them the best way of spending their money in purification works?—Suppose they did do that, they would just be in the same position that we are to-day; that is, we have no guarantee that what we are doing, although we think it is satisfactory, would be satisfactory to some Authority. You see the difficulty; they have no guarantee that whatever they do would be thought satisfactory.

29618. Then you would prefer to throw the responsibility of advising upon the supervising authority, because if the thing was not satisfactory they would have nothing further to say?—Yes, if the authority could find out some reasonable and feasible way of dealing with the effluents, they could then say to the manufacturers: "You must do so-and-so."

29619. (*Sir William Power.*) And if you do that you shall not be interfered with for a definite time?—For a definite time. If there is a better way found later on the thing could be altered.

29620. (*Chairman.*) It would be interesting at this stage if you would tell us at what cost you have obtained the results which you have been describing to us?—It is costing us just now under £100 a year for working it, but you must add to that depreciation and interest on capital.

29621. Before going further, does your £100 cover the labour only, or does it cover the labour and the cost of the precipitants?—It covers the labour and the copperas and the cost of removing. You mean the lime and copperas?

29622. Yes?—Yes, wages, lime and copperas, cartages and repairs.

29623. (*Sir William Ramsay.*) That includes disposing of the sludge?—We have got to cart it away.

29624. That includes it?—That includes it.

29625. (*Sir William Power.*) And the up-keep of the works, does it include that?—Well, the cost is very little for repairs; about £10 a year.

29626. (*Chairman.*) That you have included?—I have taken the actual cost to us.

29627. Now, what has been the capital cost of these works?—The capital cost has been £2,000. Five per cent. depreciation on that gives £100 a year and interest on capital at 4 per cent. is £80 more. Making the total cost £275.

29628. So it costs your firm £275 to purify the effluent, and you say that it is practically colourless and very free from suspended matter?—Yes.

29629. And almost neutral?—Yes.

29630. (*Mr. Tatton.*) Would that also include steam? Have you perforated pipes in the bottom of the tanks?—Perforated pipes in the bottom of the tanks.

29631. And you blow steam up through it?—Well, we use a little steam, it is more air that is drawn in.

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29632. You do not find that it uses much steam?—No, I do not reckon anything for that.

29633. (*Sir William Power.*) You pump the whole of your liquid refuse?—The whole of it.

29634. Is the cost of the pumping included in that estimate which you have given?—No, I do not allow anything for steam but the cost of the pump and the pipes is there.

29635. (*Chairman.*) Have any other firms in the same position as yourselves visited the works?—Not yet, we have not asked them or told anybody about it, because we want to get the thing right first.

29636. Do you think you have got it right?—I think we have.

29637. Then we can visit these works at any time?—At any time you like without notice.

29638. This purification plant is constantly working?—On every working day.

29639. So that we can choose our own time?—Yes, on any working day.

29640. (*Sir William Power.*) Have any of the other manufacturers in your neighbourhood gone so far as you have in experimenting to improve their methods?—I do not think they have, because the Galashiels people got such a sickener with the lawsuit that they did nothing; they have left it alone. But they are now going in for a new sewage scheme. The Burgh of Galashiels had no scheme of sewage and has not to-day, and they are to put in now a scheme for the sewage of the whole town. and they are going to take in the effluent from the mills.

29641. Are you included in the Burgh?—Oh, no, Galashiels is six miles off.

29642. You are outside it?—We are at Selkirk.

29643. (*Chairman.*) What are the arrangements at Selkirk; have they a sewage scheme there?—There I think we have had a hardship all along. When the Corporation adopted a sewage scheme and put their pipes down, they would not allow the manufacturers to run their effluents into the drains although we pay the drainage rate.

29644. In your own case, would it be practicable to run into the sewer if the sewer were large enough and they willing to receive the effluent?—Quite practicable, because as it is now we have to pump everything up to the level of the ground. It would be a simple thing to pump it into a tank and run it into the drain.

29645. (*Sir William Power.*) But are you not under an obligation to return the water into the stream, that which you take from it?—Well, I do not know that we are; perhaps we are, under the Rivers Pollution Act.

29646. (*Chairman.*) Do you suggest that, in most cases where it is practicable to do so the simplest way out of all these difficulties of trade effluents is that the authorities should receive the effluents into their sewers and deal with them together with the domestic sewage?—I think very probably it is so, and after all the manufacturers are paying the bulk of the drainage rates, and we ought to get relieved of it. But in the Galashiels case they took a special Act of Parliament for the scheme, and they have power of saying to the manufacturers, "You must do certain things with your discharges before we will take them."

29647. Obviously that must be so?—They do not know what is to be asked of them.

29648. Obviously an authority can make, and must make, conditions before receiving effluents into their sewers?—Yes, it is quite right.

29649. And subject to those conditions being reasonable you think that that is a very simple way out of the difficulty?—I think it is.

29650. But there will still remain certain cases where, either because they must return the water to the stream or because the volume of the effluent is too large for the sewers, the manufacturer must deal with the effluent himself?—Yes, probably.

29651. And you have shown us for the class of effluent that you produce, that you think it is practicable to purify it so as not to cause a nuisance in the stream?—I do, and I do not think the cost is unreasonable.

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29652. You think the cost which you have mentioned to us of £280 a year is, for a mill of your own size, not prohibitive ?—I do think it is not unreasonable.

29653. Now, do you think there should be fixed standards for each trade, and, if so, should the law provide means by which the standard could be raised or lowered according to the character of the stream ?—That is a very difficult question. My reply to that is, that so far as the woollen trade is concerned I do not think any other standard than that given in reply to (1) is necessary, provided the discolouration is not too dense, and that the effluent goes into a fair volume of clear water. We have rather a difficulty in understanding what sort of standards could be adopted.

29654. Do you think it is practicable to have standards at all for each trade ?—I should doubt it.

29655. Why do you doubt it ?—What sort of standards? I should like to hear what standards are suggested.

29656. It has been suggested to us that in certain trades a certain standard result should be aimed at and insisted upon ?—You mean an analytical standard.

29657. Yes ?—Oh, well, that comes to what I say here.

29658. In your case, you think that you would like some authority to come to you and say: "You must produce an effluent which comes within these limits" ?—It depends how wide the limits are; of course, it is rather difficult to say.

29659. (*Sir William Ramsay.*) The sort of standard one would suggest would be this, I think; that the effluent should not contain more than a certain amount of suspended matter per gallon, say three or four parts per gallon, or something of that sort; that it should not be darkly coloured, and that it should not be too alkaline or acid. To a great extent that would be the kind of standard one would lay down for such a liquor as this ?—I think that would be quite reasonable, provided there was a little latitude given, but it would never do to say it shall not be alkaline, and it shall not be acid.

29660. But within limits ?—Within limits; yes, I think it would be quite reasonable.

29661. (*Chairman.*) Would it be reasonable to apply that standard to the whole trade, or are there certain conditions which prevent an individual manufacturer from reaching the same results, for instance, that you reach ?—I do not know anything that might prevent them, except want of room in some cases to put their tanks up.

29662. There is the question of want of room, and then there is the question of the relative volume of the stream to the effluent ?—Yes, in Galashiels it would be more difficult, but Galashiels is out of the question now, because they will go into the general sewage scheme.

29663. What I wanted to get from you was an opinion whether a standard is applicable to the whole of the trade, or whether the special conditions of each manufacturer should be taken into account, and also the special conditions of the stream itself ?—I should think it would require to be dealt with, each manufacturer by himself.

29664. (*Sir William Ramsay.*) Colonel Harding, I think, has alluded to different trades here, not necessarily wool scouring, but generally to nuisances all over the country. It is a perfectly general question as to whether standards should be applicable, and, of course, in your particular case, whether you would find them hard on your particular business ?—I do not think we personally would find it hard, but I could imagine some of the manufacturers having a difficulty.

29665. (*Sir William Power.*) In attaining the standard that you have attained, do you mean ? If your results were fixed as the standard, you do not think that would be too hard on other manufacturers in the same conditions as yourself, do you ?—No, I do not think it would be.

29666. (*Sir William Ramsay.*) Might I put a question on the same point ? Do you not consider it rather a grievance that you have been put to considerable expense in purifying your effluents, and that your competitors shirk the question and are not put to the same expense ?—That is what we feel, that we are doing more than other people are doing, and we should like to see manufacturers made to do as well when we have shown them the way, but until we can show them the way, we do not care to say anything.

29667. May I put another question ? It is this: I presume the drains in Selkirk are comparatively new, or at all events have been renewed lately ?—The town's drains ?

29668. The town's drains ?—Sewage ?

29669. Yes.—No, it is thirty years ago since they were put down.

29670. Then the reason why they refused to take your effluent probably was that the drains were not large enough.—But they put them in then, and they would not take the effluents, though we have been there long before that.

29671. That is precisely what I want to know; the drains might have been put in large enough to take all the effluent ?—Quite.

29672. And they were not ?—And we asked them to do it at the time, but they refused to do it.

29673. (*Mr. Tatton.*) Do you get your water from the river ?—Yes, well, from a well. We sunk a well; the whole haughland is practically a filter bed of gravel, and the water percolates through; and we get an ample supply of water from good wells.

29674. Then you are not obliged to turn water into the river that you use in the works; you can turn it into the town's drains ?—No, because we take nothing actually out of the river itself.

29675. (*Mr. Stafford.*) The Ettrick is a tributary of the Tweed is it not ?—Yes.

29676. You are on the Ettrick ?—Yes.

29677. Are there any manufacturers above you on this stream ?—No.

29678. Any below you ?—Yes, in Selkirk.

29679. Do they purify ?—No.

29680. They do nothing ?—No.

29681. You are the only persons doing anything ?—So far as I know.

29682. On the Tweed there are River Commissioners, the Tweed Fishery Commissioners ?—The Tweed Commissioners, yes; but they have nothing to do with the pollution, except for salmon.

29683. But do they never complain of the pollution ?—I am one of the Tweed Commissioners.

29684. Well, do you never complain ?—No, we have no power.

29685. Has there been any destruction of fish life on the Ettrick attributable of course to the pollution of the stream ?—No, I never knew of any.

29686. And the Commissioners have never complained about the destruction of fish ?—The death of fish; no.

29687. I mean about the river being polluted and the fish being killed ?—They grumble often, but they have never made a complaint. because they have no power to carry it out.

29688. What I want to understand is, do they complain ?—Oh, yes.

29689. Then there is destruction of fish life upon the Ettrick ?—No.

29690. Well, why do they complain ?—Because of the nuisance.

29691. The fishery people would not complain except on account of the destruction of fish ?—Oh, yes. I have a bit of salmon fishing on the Tweed myself, through which I become a Tweed Commissioner.

29692. Yes ?—I am about four miles below where the Gala comes into the Tweed. I have seen the foul discharges coming down the river, when the river was fairly small, when we were wading in fishing; and, as my man explained it, it looked like a snowstorm in the water, flocculent stuff coming floating down; the sides of the river get foul and stink horribly.

29693. Surely that is destructive to the fish ?—No, salmon and trout are there. I never saw a dead fish caused by anything of the kind. The Tweed Commissioners for some years back have been experimenting with a view to finding out where the salmon disease

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arises. Professor Hume Patterson, in Glasgow, was the man who was carrying out this. He first of all discovered that the salmon disease that we see on the fish—the white fungus—is not the disease itself, but the result of the disease, and the disease is in reality a microbe or bacillus that gets underneath the skin.

29694. Caused by what?—That is what we want to find; but that was his first point. Then we wanted to find out what was causing this, and he took samples all over the river.

29695. Of what river are you speaking just now?—Of the Tweed and its tributaries.

29696. And its tributaries?—Yes; and he took samples. Then he cultivated the bacilli, and he got negative results and positive results. Where he was able to cultivate it, it was a positive result. The worst place was where the Gala went into the Tweed. Sir Richard Walter Griffith, the Chairman of the Tweed Commissioners, said one day that he was satisfied after that that it must be the mills pollution from Galashiels. Well, I told him I would like to see the reports, and he sent them to me after that. It was just after I joined the Commission, and I got the reports, and at first was inclined to think the same, but one thing that struck me was he got a positive result from a sample taken from the Gala a mile and a half above Galashiels where there is no factory, and where no salmon can get; below there is a weir, or cauld, as we call them, so high, so steep, that no salmon can go above that.

29697. Is that below Selkirk?—It is at Galashiels, yes, further down Tweed.

29698. That he took the samples?—He took them all over the river, from Kelso to Peebles.

29699. Did not the pollution at Selkirk affect it at all?—Well, I want to explain. In regard to this sample, which was taken above Galashiels, a mile and a half above Galashiels, Galashiels is the worst offender in the whole thing, because they have the largest number of mills and the smallest stream. I then began to look more closely into it and, I know pretty well every inch of the river there, I could point in every case where he got a positive result to domestic sewage coming in.

29700. (*Chairman.*) I think Dr. Stafford wanted to ascertain from you whether those samples were not taken below Selkirk, that is the pollution of Selkirk and your own mills?—They were taken in the Tweed above and below where the Ettrick comes in, and also in the river Gala, because he found that was the worst place.

29701. (*Mr. Stafford.*) It would not be unreasonable to ask these other people to do as much as you are doing on the Ettrick?—I do not think so. I do not think it would; that is my whole point. We have felt that we are doing more than they are, and we get no benefit.

29702. And there is considerable pollution in the Ettrick whether it affects salmon or not?—There is not very much comparatively.

29703. (*Chairman.*) There is on the Gala?—There is on the Gala and on the Teviot.

29704. Do you think that the manufacturers in Galashiels may be able to attain the same results that you have been at something like similar cost?—Oh, Galashiels is out of the question because of this general sewage scheme.

29705. It will not be necessary for them because it will be taken into the sewers?—It will be taken into the sewers. In Hawick it is different; Hawick has a scheme for treating their sewage which they have had working for years. Dechan, the analyst, who gives that analysis, took it up for a time, trying to make something of it, and he could not. He gave it up, and since then it is practically not in operation at all, and the Teviot below Hawick is very bad.

29706. (*Mr. Stafford.*) You speak strongly about crippling an industry. Of course, what you have done, if it were done generally by the other manufacturers, would in no way cripple the industry?—No, I do not think it would. That was more in reply to the general remark for other industries as well. I do not think there is any difficulty with the woollen industry.

29707. No question would arise of crippling the industry if the others were asked to do as much as you have done?—I do not think it would, not in the woollen industry.

29708. (*Chairman.*) Well, we thank you for your attendance, Mr. Roberts. We have been interested to find a case of a manufacturer who, as far as we could judge, without any external pressure, has thought it necessary to carry out works for the purification of his effluents, and we shall no doubt take some opportunity of visiting the works and judging for ourselves of the results that you have obtained. Meanwhile, we thank you for coming before us?—Well, I can only say again that we are very anxious that the river should be kept pure, and I think there is no reason at all why it should not be, as far as our industry is concerned, and I hope that if you send anyone to see the work that you will do it without sending any intimation whatever, so that you can see by a surprise visit.

Mr. JAMES H. ANNANDALE, Mr. WILLIAM LEONARD TOD and Mr. ARTHUR LAW, called in; and Examined.

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29709. (*Sir William Ramsay*) (*in the Chair.*) You represent the Scottish Papermakers' Association?—(*Mr. Annandale.*) Yes.

29710. Is it a large body?—Well, it represents the whole of the papermakers of Scotland, about fifty or sixty; but at the same time our membership does not include the whole of them; they do not all belong to us, though they have belonged at various times, but some of them have found, of course, that they do not get much advantage from it and they have not attended regularly.

29711. Are the papermakers of the Don and the Dee—are all the rivers represented?—Well, they are not represented though they are generally at one with us in our deliberations. They correspond with us, but they do not pay anything to the funds of the Association. (*Mr. Tod.*) I think some of them are, I do not think the Piries' are members, but I think some of the other manufacturers up there are. (*Mr. Annandale.*) They are generally at one with us, but you may take anything we say; they are fairly at one with our ideas on the subject.

29712. Is it a fair question to ask: For what does this Association exist? not entirely for the rivers pollution question?—Oh, no, for all trade questions.

29713. For all trade questions?—All trade questions come before us.

29714. Then to read from your notes: you think that the first principle to be positively asserted is that every manufacturer is bound to use all reasonable measures known to abate polluted discharge of either gaseous or liquid impurity from his works. We are here dealing merely with liquid impurities?—Yes.

29715. Then you think it would be difficult to fix a standard at an early stage like this, because the known means have to be collected and the effect of these cannot now even approximately be estimated. You must take local conditions into account, especially the state of the purity of the stream or otherwise above any mill. I presume you would also say the size of the river ought also to be taken into account into which your effluent is discharged?—The general conditions.

29716. There are so many variations in working, even in a given trade, that it would be unreasonable to fix at once a universal standard for that trade, though ultimately such a standard within moderate limits might be arrived at. In papermaking the variation in the conditions of the different mills is very marked. Do you not think that some standard might be devised of a very elastic nature for the present, a low standard let us call it, to which it would not be difficult for the various papermakers to accommodate themselves with the object of ultimately, when better means of purification are discovered, raising the standard?—Well, of course, if you use the standard to suit the worst polluting mill the other mills would very easily come up to that standard. For instance, I am just giving you an instance of one; the mills that use very, very coarse material, and, of course, that use very strong chemicals and cannot recover these chemicals at all, and in some cases that again can produce an immense deal of dirt, would naturally require to have

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a very low standard, but taking myself, for instance, who make only the finest classes of papers from rags, we who use little chemical and use high-class material, would very easily come within that standard or any standard of that kind.

29717. Do you think that a standard when it is made should have regard to the nature of the effluent or the nature of the effluent taken into account along with the amount of the dilution of the effluent when it reaches the river ?—I think the proper standard would be the quantity of effluent and the virulence of it, calculating by the size of the works, taken by machines. Of course, for papermaking the size of a mill is regulated by the number of machines, or its out-turn perhaps, which is the fairest way, the out-turn per week, and then each class of mill would require to have its own particular standard, which would even then require to be more or less elastic, for you cannot define exactly the qualities a mill makes. Now, for instance, a class of mill like a rag mill, the old fashioned mill which makes the finest class of papers has quite a different effluent from the esparto mill which uses esparto, and has to reduce esparto from the vegetable state you understand, preparatory to making paper.

29718. You next speak of the various methods for purifying trade effluents, your particular trade effluents, the recovery of the soda leys and the working of the boiling process to make this recovery of the fullest efficiency. You think that the soda leys ought to be evaporated and then incinerated ?—In cases where that can be done.

29719. Can it not always be done ?—It cannot be done, for instance, in cases where the leys are very, very weak, because it becomes not only extravagant in the evaporation of these very weak solutions, but also you cannot recover owing to the want of vegetable matter to incinerate, to burn afterwards.

29720. Then the complete exhaustion of the chloride of lime in order to extract the fullest quantity of chlorine and leave as thoroughly a spent lime as possible. Is it possible to exhaust the whole of the chlorine ?—Well, you can exhaust it to a very great degree, and, of course, with a very good plant and good arrangements it is economical to do so, so that it is no hardship to a papermaker to be made to use his chlorine as far as he can from his chloride of lime.

29721. I think we have seen a mill in which there was no effluent from the spent chlorine liquor which was used ?—Yes. I do not think there is really anything comes away from our mills except after having been used through our process, and, of course, the spent lime.

29722. The spent lime ; that is a solid product which can be carted away and stored ?—Carted away or else, as is very often done, used in the effluent in the settling ponds which are being used now, and it rather helps the other precipitation.

29723. Then you speak of (3) the precipitation of the solid matters of all waste waters by means of an improved system of settling or even simple filtration arrangements. Have you not considerable difficulty in disposing of your paper pulp that is too fine, that passes through the gauze ?—As a rule, of course, the gauze takes out the bulk. In our particular case we pass all our waters through what we call save alls, that is to say, revolving wire screens which take out the fibre pretty well, and then the rest is settled in the ponds pretty much by the other things we use, such as alum. We use a certain amount of alum in papermaking. That brings down the fibres very much in the settling ponds, and our water effluent in our case is very often as clear as that (*Indicating water in a water bottle on the table*)—though, of course, it is not as pure. (*Mr. Tod.*) The disposal of the solid matter is certainly a very serious question, because various things have been tried to get a use for it, but so far no use has been discovered. A number of years ago the Scotch Papermakers Association offered a prize through the Society of Chemical Industry for any commercial method of disposing of these waste products, and a large number of samples of these products were sent out, and we got several suggestions made but none of them were commercially possible. At present all the refuse has to be taken and carted and laid down on waste land, and it is a serious question because in my own mill, which is just a small mill, the amount of the refuse, the precipitation of the solid matter from the machines, the bleach lime and the carbonate of lime, from recausticising the recovered soda, these three together amount in my case to something like 3,500 cubic yards per annum.

29724. Practically about that number of tons ?—Yes, well we put it down on waste land. It means, roughly speaking, 30 inches of a heap per acre in a year.

29725. That is a very large quantity ?—That is a very large quantity, Sir, and that is undoubtedly a very serious matter for papermakers, those whose ground is limited.

29726. I suppose the savealls catch a great deal of the fibre ?—Oh, yes they do.

29727. They are not universally used, however, are they ?—No, not in all cases. They have advantages, but they have also disadvantages, because they catch fibre and they also catch dirt and one gets a lot of dirt in them. We made some tests from one of those save-alls, and I think, speaking from memory, there was something like 120 grains to 1 gallon of solid matter in the water running into this saveall, and something like 90 grains per gallon were taken out and used over again.

29728. Then in the subsequent purification process you spoke of alum I think. Mr. Annandale spoke of the use of alum ; is that added in excess or is it part of the process of papermaking ?—It is part of the process of papermaking. (*Mr. Annandale.*) It is part of the process of papermaking.

29729. It happens to be there ?—It happens to be there.

29730. Is anything done to precipitate it in the septic tanks ?—(*Mr. Tod.*) It is a solution ; it is used, if I may state, mainly for the size. The size is made of a solution of resin and this is precipitated in the fibres of the pulp by alum or alumina.

29731. Which must be in excess ?—Which must be in excess.

29732. Also this sulphate of alumina helps to fix the colouring matter in the paper ?—This goes from the machines to the settling pond and we found that sometimes, if the water was specially turbid, a little extra alum added to it helped it to settle.

29733. But you do not do anything to precipitate the alum in the shape of any lime or alkali so as to make the alum come down ?—No. (*Mr. Annandale.*) But you see there is a certain quantity of lime and a certain quantity of soda in our waters, the effluent.

29734. Which ?—It is the mixture of these chemicals which has a very rapid precipitating effect, and that is why we get our water sometimes so remarkably pure. (*Mr. Tod.*) And the slight acidity from the alum also helps to neutralize any traces of soda there may be and give a comparatively neutral effluent.

29735. Then you speak, lastly, of the carting away of solid refuses, as ashes and limes, used in recovery, etc. There should be an authority to assist for the provision of sites on which to deposit such refuses. That is altogether a new point is it not ? Of course, very often a paper work has not ground enough to spare. It is not possible to buy enough ground in the neighbourhood ?—Sometimes. Sometimes it is not. (*Mr. Annandale.*) Of course, in cases where it is possible, where there is waste land or old quarries to fill up, it is very convenient if you could get power to do that.

24736. It is no use as a manure, I suppose ?—It is no use as a manure.

29737. There is another point which you have mentioned, and that is the colour of the water. If you are making white paper there is no colour in the effluents ?—(*Mr. Tod.*) No, practically not, but even in the case of white paper, a paper like this (*Exhibiting sheet of white paper*) there is a certain amount of colouring matter used, but it is so slight as not to affect the colour of the water. (*Mr. Annandale.*) And even in making coloured papers there is much destroyed by the waste bleach. Of course, we cannot exhaust the bleach entirely in our fibre ; some goes away in the effluent.

29738. We have seen on our visits very coloured effluents run away—dark green, blue, and red ?—(*Mr. Tod.*) In mills that make coloured papers.

29739. That is a serious business ?—Well, it is practically impossible to avoid that entirely; it is quite reasonable to consider or call this an innocuous discolouration which, I think, is an expression used in one of the Pollution Bills.

29740. I do not suppose colouring matter *per se* is any particular harm, because there is so very little of it ?—There is so very little of it, and it is almost entirely aniline nowadays.

29741. And very small quantities at that ?—And very small quantities at that. (*Mr. Annandale.*) And very small quantities.

29742. Do you think that the state of affairs in the North Esk river is satisfactory at present ?—(*Mr. Tod.*) I think on the North Esk we have probably got purification carried further than anywhere else in the country.

29743. There is a question arises in connection with that: Is there anything in the shape of an authority to look after the purity of the rivers in that part ?—Well, Mr. Annandale can speak of that more. (*Mr. Annandale.*) At present the Duke of Buccleuch and other riparian proprietors—perhaps you know all about that action—we have passed through various agreements with the Duke's agents in regard to the examination of the river. The last examination took place with Dr. Stevenson Macadam, and we practically worked to his hand under an inspector who reported to him regularly. There was some dispute arose about the continuation of the thing, and it has now fallen into abeyance, but at the same time, under the Duke's supervision, there is still an inspector who from time to time visits the mills, but there is no real organised inspection now going on more than this man who generally looks after our keeping up our present plants.

29744. Then the only inducement to the purification of the stream from the paper makers point of view is the threat of an action in the Court of Session. I suppose from the riparian owners ?—That is the position of matters. (*Mr. Tod.*) Well, there was that on the Esk some fifty years ago, and it went against the papermakers, and, as Mr. Annandale points out, we have ever since then been working under agreements until the last one.

29745. There are no present difficulties ?—There are no present difficulties; we are all keeping up our arrangements, and we consider it is only right that we should do so. (*Mr. Annandale.*) The last Report of Dr. Stevenson Macadam which was given both to us and to the Duke's and other riparian propretors' representatives was to the effect that the papermakers had done on the stream all that was reasonable and proper and that they had really satisfied him that they were giving a very pure effluent, and that the present principal amount of pollution that was in the river was dependent upon mines and sewages, so that we were practically exonerated by Dr. Stevenson Macadam of being what you would call the grave polluters. That we will be polluters goes without saying as long as the mills last.

29746. But do you think that this system is preferable to what the Commission have already recommended, that there should be Rivers Boards all over the country who should concern themselves with the purity of the rivers, instead of being compelled as it were to keep your effluent pure by the possibility of an action with the riparian owners or by agreement with the Rivers Board. Once the matter could be put under the control of the Rivers Board its business would be to see that the river was not polluted, not only by trade effluents, but in every other way—domestic sewage ?—That is the proper way to look at it. We suggest a Rivers Board, and that Rivers Board could look after distinctly every kind of pollution. (*Mr. Tod.*) We certainly think that would be better than any private legal action or arrangement. (*Mr. Annandale.*) I think that the whole of the manufacturers in any stream would always welcome anything of that sort in which they were all included, and that has been a great grievance with us on the Esk that while we were doing our very best there was no effort made by the prosecuting parties to purify either their own mines or the sewage that their own villages were making, and naturally, of course, they are put into a very difficult position, when their own inspector—really he was their own inspector—Dr. Stevenson Macadam, pronounced that we were not guilty to the extent that their own villagers and tenants were.

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29747. May I ask whether, in the rag mills, no attempt is made to recover the soda; are the liquors so weak ?—The liquors are exceedinlgy weak, and they are just simply settled and then run in with the rest of our effluent.

29748. And the alkalinity of that soda is neutralised by the alum that is used ?—To a certain extent the fact of the matter is, so very weak is it that if you leave it lying long enough to allow fermentation to take place, the fermentation destroys the alkalinity and makes it neutral.

29749. It is very slightly alkaline ?—It is very slightly.

29750. A further remark in your proof deals with the general law, I think, not merely in Scotland, but in England also, namely, that the manufacturer is bound to restore the water he uses from a river or stream un diminished in quantity and unimpaired in quality from which he takes it. Well, that, of course, is interpreted rather liberally; it is often done there; it is so ?—Yes.

29751. I see you make rather an unusual suggestion; you think when there is a large flood it ought to be allowable to wash out accumulated discharges, to allow them to go ?—I think distinctly with the less virulent discharges it would be a very good thing, in fact, with the river coming down in flood there is no discharge that could do any harm to anyone either on the banks or to fish on the stream.

29752. But you state here that accumulated sediments should be washed in ?—Yes.

29753. You would not include under that, for example, spent lime, would you ?—I do not think spent lime would do the slightest harm.

29754. It would deposit in the bed of the river ?—Not in a full flood.

29755. Well, somewhere it would; it would deposit in the estuary ?—It would deposit in the estuary undoubtedly but it would not do any harm in the estuary, not the slightest; it is so exhausted, you know.

29756. Yes, but there is such a very large quantity of it; would it not silt the river up ?—What I am alluding to is, what is deposited in the ponds. All the lime which has been described by Mr. Tod just now is already carted away; that is never used in that way at all.

29757. It is what would be deposited in the ponds ?—It is what is in our settling ponds for the deposit of the mill effluent not for the spent lime that he refers to. (*Mr. Tod.*) Of course, the spent lime from the causticising; certainly we would not think of putting that in. (*Mr. Annandale.*) No one would think of putting that in. (*Mr. Tod.*) But simply washing out the settling ponds; if that could be done when there is a flood it would undoubtedly tend towards getting a better normal result, because they are very difficult to drain when they have lain for some time. (*Mr. Annandale.*) That very, very fine sediment; it is, of course, the very, very finest sediment I allude to.

29758. It is very difficult to settle ?—It is very difficult to settle and very difficult to get rid of after settling; it will not drain dry; it is such a very fine mud it will not part with its water. It is with the view of getting that away in times of flood; it would keep our ponds so very much purer. After lying long it ferments and rises to the surface, and therefore causes pollution; in fact it destroys even the action of our ponds. (*Mr. Tod.*) I do not know if the Commissioners have seen a paper mill.

29759. We have seen several; we have seen several of those ponds, but I do not remember noticing that fact you speak of, the aerobic fermentation of the pond ?—Well, you would hardly see that because it would probably be covered with water, but when they are drying, well, they are rotting.

29760. The size, I suppose, is the cause of that very largely ?—And the starch. (*Mr. Tod.*) And the starch, the vegetable matter. The ponds are generally in several compartments. The first compartment has to be emptied every week or ten days. With that there is no trouble; that settles easily because it is the heaviest and most open matter which is in it. In the latter compartments it is much finer and sticks so closely together that it is very difficult to drain it. Perhaps it has lain three or four months sometimes much longer without the ponds being emptied. Well it smells a little, but the

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quantity of that compared with the flow of the Esk even, which is a small river, is very small. The whole of the ponds of the mill would not be equal to a second's flow of the stream in flood.

29761. A very small fraction ?—Yes, it would not be nearly 1 per cent. ; it would never be over.

29762. (*Colonel Harding.*) Upon this point may I ask what is the utility of settling this fine matter at all if you suggest that it should afterwards be sent to the river ?—(*Mr. Annandale.*) To keep up the normal purity of the river. (*Mr. Tod.*) If we allowed it to run into the river constantly it would be very polluting ; it would make our rivers very turbid. As it is we collect that in the ponds and the effluent is not absolutely clear, but it is very nearly so. At present all that solid matter is laid down in these heaps, but I think, if at the time of high flood, when it would make no difference, when it would never be seen in the river, we were allowed to wash these ponds out, we would get better settling at times of low normal water ; therefore a purer average effluent.

29763. So that what you would so settle out would not be kept out of the river, but would be sent into the river at certain times ?—A small part of it, at certain times when it would do no harm.

29764. That is just the point, is it not, whether it would or would not do harm, because the greatest objection has been made in some districts to the sludging out of reservoirs merely for holding up the water for the purpose of the mill, and these have at times been sludged out and very great objection has been found to that course. Could not the sludge be run out upon lagoons and dried or otherwise ?—It is run out at present ; there is none of it put into the Esk at present ; it is run down out of these ponds on to ash filters and allowed to drain, and then carted away to this heap. That forms part of this 3,500 cubic yards that I spoke of.

29765. That seems a much more satisfactory way of dealing with it than sending it to the river again, after you have settled it ?—Well, we merely suggest this. (*Mr. Annandale.*) It would help the purification of the stream. (*Mr. Tod.*) We think it would help the normal purification.

29766. (*Chairman.*) It is an alternative method in point of fact. Do you not think this sludge would ultimately settle in the bed of the stream ?—(*Mr. Annandale.*) Never ; never under a flood. I think this is a question very much for the Commission to satisfy themselves upon by observation. We make a statement, but at the same time I would really strongly support that it should be closely checked by observation.

29767. You think it is an experiment worth trying ?—We think it is an experiment worth trying.

29768. Then, you recommend that a council should be formed in each river district, that is to say a Watershed Board. You would call it the River Watershed Board ?—Quite so.

29769. Which is not dependent upon each county, but is connected with the river itself and with the tributaries, the river watershed ?—Yes.

29770. That we have already recommended, but we have suggested that such Watershed Boards which do exist should be subservient to a Central Board in London ?—Certainly.

29771. Which could see that they do their work and help them, if possible, by advice in difficult cases ; that is very much our recommendation ; do you agree ?—Yes ; perfectly right ; there should be a Central Board.

29772. In dealing with your own refuse, would it be possible, in many cases, I do not know whether in yours, that two effluents should be brought together and treated in the sewers and treated along with the domestic sewage ?—In certain cases it might do, but the mills are so widely distributed.

29773. They are not in towns ?—They are not in towns, paper mills are generally in the country. But I believe it would be a good thing for the sewages to be mixed up with some manufacturing refuse, because there is sometimes a little excess of chlorine or alum which would always help.

29774. Oh, it does help, it is all of advantage. Is it possible that your Papers Makers' Association, as a whole, could offer rewards or prizes for the discovery of a process for satisfactorily dealing with any special kind of pollution ?—Oh yes.

29775. That could be done ?—That has been done. (*Mr. Tod.*) That has been done ; I mentioned that.

29776. But without any particular effect ?—Various suggestions were made but none of these were found commercially possible.

29777. I made a suggestion of the kind myself, but again it does not appear to commend itself. It might in some cases. It is causticising the recovered soda by means of iron instead of lime, in which case you would avoid any sludge from that particular process ?—Well, I have heard that spoken of, but I believe it was tried somewhere and not found successful.

29778. It is very successful in Brunner, Mond & Co.'s works for making caustic soda, but whether it would work in your particular case I do not know. You would get rid of that particular kind of waste, the amount of carbonate of lime you get in causticising soda ?—It is about half the whole.

29779. It would be worth while inquiring into that, but that is a question that ought to be investigated by itself ?—(*Mr. Annandale.*) I should suggest a note to be issued. We suggest further on, if you notice, that there should be one mill taken in hand by the Commission, so to speak, and these things thoroughly tried and tested. I think if anything of the sort would be of advantage to us commercially, or in getting rid of our pollution, we would be all willing to accept a little tax to pay the expenses of any of these experiments.

29780. Quite. Then there are several cases which would press rather hardly on you, would they not ? For instance, in your district there is only one mill that makes its own wood-pulp, and produces sulphite liquors. The sulphite liquors concern the proprietor of that particular mill, and would not concern any other paper maker ; in that case the mill owner should be obliged to work out his own salvation, do you not think ?—Yes, I think in some of those special cases it would make some little difficulty. (*Mr. Tod.*) He would be rated at a higher rate.

29781. No doubt he would ?—He would be rated proportionately.

29782. (*Mr. Stafford.*) Is the North Esk a salmon river ?—(*Mr. Annandale.*) No.

29783. No question of fish arises ?—Well, there is sea-trout fishing down near Musselburgh. After it has been joined with the South Esk there is very good sea-trout fishing at the estuary, and up above the estuary for two miles, but it originally was a river which salmon went up. For instance I heard my father say that there was plenty of salmon in the river in the beginning of the last century.

29784. Is there any fishing village to interfere with, or cause a pollution of the stream ?—No, nothing of that sort except a club down about Musselburgh that used to make a little noise. In fact it is comparatively lately that this little club has been formed for fishing the lower reach of the Esk, since in fact the river has been so much purified.

29785. When you speak of inspectors I presume you refer to the Sanitary Authority ?—We have had no trouble with the Sanitary Authorities ourselves ; all our trouble has come from this action of the Duke of Buccleuch and other riparian proprietors. The Duke of Buccleuch, of course, has got the town of Dalkeith on his property. It drains at present right into the Esk. All up the upper reaches of the river is polluted by other villages. Pennycuik runs all its sewage into the Esk ; Rosslyn, Lasswade and Loanhead, and then you have got Dalkeith, all discharge their sewages now into the Esk. It is a very healthy district, owing very much I think to the discharge of the paper mills neutralising the sewage, but in case of a flood just now the discharge of accumulated sewage is most marked, and in the summer time if we have a long drought the smell is very bad ; the water smells very badly of sewage.

29786. (*Chairman.*) Does it interfere with the water that you use for paper-making purposes ?—Oh, our water for paper-making purposes is generally taken from purer sources, from tributaries or from artesian wells.

29787. Not all from the river ?—Not generally from the river. We can use some of the river water for certain purposes ; for instance we use it for our boilers, filtering it first, and it does fairly well, but there is a great deal of sludge in it.

29788. (*Mr. Stafford.*) Do I understand that no difficulty has arisen with the Sanitary Authority in connection with the pollution of the Esk ?—No, we have never had any trouble. (*Mr. Tod.*) No, I have never had any trouble. (*Mr. Annandale.*) The question has never been raised. (*Mr. Tod.*) The question has never been raised by the Sanitary Authorities. Of course we have had the Inspector appointed by the riparian proprietors.

29789. By the riparian proprietors ?—By the riparian proprietors who brought this action. He was appointed by the proprietors, and the mills have been working under his supervision. He, or his assistant, could come into the mill at any hour, day or night, and if he made a suggestion we had to carry it out. But that is the only inspection that we have had, a mutual arrangement between the proprietors and the mills.

29790. With the idea of keeping the river clean ?—With the idea of keeping the river as clean as we could possibly get it. (*Mr. Annandale.*) I may tell you there have been attempts made among the villages to purify the sewage. Both at Pennycuik and Loanhead. I do not know whether it has been done at Rosslyn, but there have been some small attempts made. I do not know that it has been done very regularly. In the case of this Commission bringing forward rules and regulations it would improve the river very much for all concerned.

29791. Have you spent much money upon your system ?—It is incalculable the amount of money spent on the Esk. I do not suppose the amount of money, spent first and last on the Esk, can be under £150,000.

29792. The capital sum ?—The capital sum. The annual expenses I can give you, I think. I have here a little note. I thought, in case we were asked these questions, I would bring out a note. As far as we can make out in our small mill alone, as it stands just now, and for various experimental plants you can multiply it by 3 or 4, the expense in 1902 runs to about £2,000 for the actual plant at present existing, and we are very small indeed for it is a very pure effluent ; we make very little pollution compared to other mills, and the annual expense to us runs to about £292 per annum.

29793. How many other manufacturers of paper are there on the Esk ?—Well, of course, we are one of the smallest manufacturers on the Esk ; we make particularly good paper. (*Mr. Tod*). There are six mills and fifteen machines. (*Mr. Annandale*). On the upper reaches of the North Esk there are fifteen paper machines.

29794. Are they all spending money ?—They are all spending money, sometimes really in much larger proportion. For instance, in the case of Mr. Tod he can tell you better. (*Mr. Tod.*) I cannot say exactly. (*Mr. Annandale.*) I do not think it is possible to estimate what it would cost. Take for instance the pollution case itself, that cost £30,000, that has been spent against pollution on the river. Then there have been all kinds of experiments tried, not only by the paper makers, but for recovery processes. Some people came forward and offered to put down plant, if they were allowed half the profit and they were very unsuccessful most of them and the amount that was spent on experiments there was something enormous, I am sure £150,000 altogether.

29795. Within what period ?—Well, you may take it fifty years. Yes, it is nearly fifty years since the question was raised on the Esk. (*Mr. Tod.*) To put in the plant as we have it now, which is really very successful, to prevent pollution, would cost I think for a moderate sized mill £10,000 to £12,000.

29796. Is the paper trade, may I ask, at the present time in a very flourishing condition or are you feeling the effects of competition ?—No ; oh, we feel it very badly indeed.

29797. Would you regard this as a very serious tax ?—A very serious tax, but it is one of those that we must submit to, although we do not like it.

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29798. But it is not prohibitive ?—In the meantime it is not prohibitive because the paper trade, as a rule, has been a very fairly successful trade. It is not a trade in which you make vast fortunes, but it is a very regular trade as a rule and the profits are much more regular than they are in other branches. It is not so affected by speculation. For instance the yarn trade affects all the manufacturers of yarn goods very strongly and mines are affected, of course, as you know, by so many different things—strikes—but paper has always been a very regular trade yielding a small, a comparatively small profit, but a very fair one up to this time.

29799. In fixing standards very great caution would have to be taken so as not to handicap the trade ?—Certainly, I think that would be perfectly easily arranged. We have been perfectly frank in telling you what the position of matters is and the experience got on the Esk would help very largely of course in trying to get a standard of purity for the country.

29800. What have you done in getting satisfactory effluents ?—We have been very very strongly dealt with and we have brought the very best experience we could get in the country to bear upon it and the results are acknowledged by the other side, by the riparian proprietors ; they acknowledge they are very good. The Esk is still a very badly polluted river.

29801. But there is another side ?—I am talking of the riparian proprietors who are against us.

29802. Are they protesting still or are they satisfied ?—No there has not been any protest lately because, as I explained to you, their own inspector, approved by themselves, Dr. Stevenson Macadam declared that most of the pollution of the Esk proceeded from sewage and the mines and not from paper making processes.

29803. I take it there has been some difficulty with the riparian proprietors from time to time ?—Of course, we have been fighting them for the last fifty years. (*Mr. Tod*). We fought them fifty years ago and we have been working ever since under the supervision of a man of skill —that is what he was called ; a man of skill—appointed mutually by them and the paper makers.

29804. There is no fight at present ?—(*Mr. Annandale*). None whatever.

29805. They are satisfied now you have got to a certain standard which is satisfactory ?—I think they are satisfied we have done as well as we could, and I think they are satisfied now that if they were doing any more they would require to bring in—and we have asked them to bring in, that we would support even—a measure that would bring in the sewage and the mines as well. But they are frightened to attack mine-owners and they have had some little correspondence as to the sewage of the different villages, but nothing has come of it. I may tell you we were very glad indeed of this opportunity of giving evidence, because we think this Commission is a most valuable thing for the whole country and would be the best protection that really a reasonable manufacturer could have, that rivers should be dealt with as a whole not that individual manufacturers should be attacked by private interests.

29806. (*Chairman.*) You have given us a statement of what you think the general expenditure on attempts to put up purification plant, but that does not include annual upkeep does it ?—(*Mr. Tod*). No.

29807. Is that very considerable too ?—The upkeep of the incinerator for incinerating the soda liquor is very heavy.

29808. But surely you make a profit out of that ?—Oh, undoubtedly we make a profit out of the soda and in the esparto mill the profit made from the recovery of the soda will pay for the whole of the expense for avoiding pollution, but on the other hand, if we had only to evaporate the strongest of our liquor and could run the weaker solution into the river, then we would make a very much larger profit, but on the Esk and in our own mill, even the washings of the floor, of all the floors, where the boiled esparto is, have to be run into tanks and evaporated and the esparto, after being boiled, is steeped in four different waters and every drop of them is afterwards evaporated.

29809. It is a very heavy expense ?—Of course that is a very heavy expense. Although the soda recovery process on the whole is remunerative it would be very much more

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so if we could only evaporate the strong liquor and run away the weak. The recovery plant, the incinerating part of it, is very expensive to keep up; it only lasts on an average about three years; at least it has all to be relaid with fire-brick every two or three years and so the up-keep is very heavy in that case.

29810. (*Colonel Harding*). I would just like to ask another question; your Association is, without doubt, acquainted with the circumstances under which the paper trade is carried on abroad ?—(*Mr. Annandale*). To some extent.

29811. Are you able to give us any information as to how far any pressure has been brought at this time against foreign paper makers for the purification of their effluents ?—I never heard of any measures being used at all abroad for the purification of the rivers. Their rivers are generally much larger than ours, you do not see the pollution, but I never heard of any measures being used by paper makers abroad; I have no experience of it.

29812. (*Chairman.*) There is a movement in Germany for the prevention of the pollution of their rivers; I thought you might know the conditions under which paper-makers are working ?—(*Mr. Tod.*) No, I am not aware, and I do not think it has been discussed by our Association.

29813. Of course, if there are no steps taken abroad to tax the manufacturers to prevent the pollution of rivers, it gives them an advantage over you ?—(*Mr. Annandale.*) Oh, it does. As I pointed out it is costing us £300 a year, independent of interest on capital, to keep our remedial measures going, and we get no return from it; we cannot recover. (*Mr. Tod.*) I may say with regard to foreign mills that esparto is not used at all in foreign countries for paper making; only wood pulp or some pulp or rags, and as a rule a paper-maker does not produce his own wood pulp, he buys it from a wood pulp-maker, and where you have wood pulp to deal with you have not nearly so many chemicals, and therefore not nearly the same difficulty in disposing of the effluents.

29814. We are very much obliged to you for giving us this opportunity of hearing what you have to say; no doubt it will be very useful to us in making our Report ?—(*Mr. Annandale.*) You are very welcome; if anything can be done in any way.

COPY OF LETTER SUBSEQUENTLY RECEIVED FROM MR. W. L. TOD.

Springfield Paper Mills,
Polton, Midlothian, N.B.
November 4th, 1909.

DEAR SIR WILLIAM RAMSAY,

On going over the proof of evidence given before the Sewage Commission last week, I am afraid we failed to make one point quite clear to the Commissioners. If our suggestion regarding flushing of settling ponds in time of flood were carried out, only a very small percentage of the solid matter deposited in the settling ponds would be returned to the river, not more than 4 or 5 per cent. at the outside. To show how this comes about I will explain fully the working of the ponds at our Mill here.

These ponds are divided into six compartments. The whole of the effluent running into the first compartment, overflowing from there into the second, from the second to the third and so on. Between 85 and 90 per cent. of the solid matter deposits in the first compartment, and 10 to 12 per cent. in the second, only about 3 or 4 per cent. passing to the third and later compartments and settling there.

The first compartment is emptied on to an ash filter bed every week or ten days, this drains easily and in four or five days is sufficiently dry to be lifted and taken to the refuse heap. The second compartment is emptied about once in three to four months also on to an ash filter bed, but this takes much longer to drain, often a month to six weeks, as the solid matter is so fine that the water cannot pass through it readily. Later compartments are only emptied at long intervals, from two up to as much as five years, and it is almost impossible to get them to drain at all owing to the sediment being so very fine.

If a system of flushing out ponds during floods were permitted, it would really not be worth while flushing out more than the four later compartments which contain, as I have said, only 3 or 4 per cent. of the total solid (*see* P.S.), and it would be a waste of labour to do this oftener than once a year. In this time the amount of solid matter deposited at the bottom would be very small, not more than 6 inches on the average over the four ponds. These four ponds have a capacity of approximately 14,000 cubic feet, the greater part of which after a year's running would be comparatively pure water, the percentage of actual dry solid matter being probably under 10 per cent.

With an 18-inch pipe, these ponds could be washed out into the river in about two hours. The Esk passing our mills when in fairly high flood is from 30 to 40 feet wide, about 6 feet deep, and flows with a velocity of 6 to 8 miles an hour. The 14,000 cubic feet from the ponds running into the river in two hours would therefore, I calculate, be distributed over fully 14,000,000 cubic feet of river water, which is 1 in 1,000, or if the solid matter is alone taken into account, then it would be a mixture in the river of 1 in 10,000, and I think that the Commissioners will agree that such an admixture could not have any appreciable effect on the river. Of course, regulations would have to be made regarding any such flushing arrangements, more particularly as to the height of the river before it was permissible.

I am sending you a bottle showing you an average sample of our effluent as it runs into the river. This may be of interest to the Commissioners, and I am also sending you two or three of the quarterly reports by Dr. Stevenson Macadam, the Inspector appointed under the agreement between the riparian proprietors and the paper makers which we mentioned in our evidence, as these also will probably be of interest to the Commissioners. I shall be glad to have these back at your convenience.

I have shown this letter to Mr. Annandale and he fully agrees with all that I have said. He has also sent over a sample of his effluent so that the Commissioners may see what two different mills on the Esk have been able to do in avoiding pollution.

Yours faithfully,
(*Signed*) W. L. TOD.

P.S.—Even if all six ponds were emptied into the river during a flood, and the first and second compartments *happened at the moment to be absolutely full*, the amount of solid matter which would pass into the river would only be about 8 per cent. of the annual production.

The Rt. Hon. The Earl of IDDESLEIGH (*in the Chair.*)

Mr. H. A. D. WATHEN, Director of Messrs. Alex. Pirie & Sons, Ltd., Paper Manufacturers, Bucksburn, Aberdeenshire, called in; and Examined.

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29815. (*Chairman.*) You come before us representing Messrs. Alex. Pirie & Sons, Ltd. ?—Yes, my Lord.

29816. Who have made paper on the River Don for over 100 years ?—Yes.

29817. And paper of a high grade ?—Yes, my Lord.

29818. Then perhaps Colonel Harding would be so good as to undertake the Examination-in-Chief.

29819. (*Colonel Harding.*) Would you please indicate to us what are the chief sources of pollution from your works ?—By that question you mean any kind of pollution ?

29820. Yes, what is the nature generally ? If for any reason you do not wish to enter into details, just give us generally an idea of what is the nature of the polluting processes ?—The dusting of esparto and rags, lime refuse from the treatment of carbonate of soda to make it caustic; alkaline waste liquor from the esparto and boiling in caustic soda; lime waste from the manufacture of bleach liquor, and waste from the general machines. That is supposing all that was put into the effluent. All

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of that is not put into the effluent; I do not mean to say that that is all put into our effluent.

29821. These are polluting sources that do not necessarily reach the river?—No.

29822. Would you in your own words and generally indicate to us how you, as far as possible, reduce the danger of pollution to the stream which passes your works?—Yes, Sir.

29823. You eliminate certain matters altogether?—Altogether.

29824. And you treat others?—Exactly so.

29825. Will you just explain to us exactly what you do?—No dusting of esparto or rags goes into the river at all; that is all caught and dealt with, either sold or burnt. No refuse from the manufacture of soda or from the bleach powder goes into the river. The whole of that is removed bodily and placed on land some distance from the works. As regards alkaline waste liquors, we recover about 70 to 75 per cent. of the soda used in the works. Is it necessary for me to describe how it is recovered, or will it be taken as understood that it is done in the ordinary way?

29826. If you will quite briefly do so. The process we are already familiar with, but it is useful to have it down on our note.—Perhaps I might read out what I have said here; it will simplify matters.

29827. If you please.—When the esparto is boiled the liquor in which the boiling has taken place is sent down to a recovery plant and evaporated, the soda recovered being again used. After the boiling liquor has been expelled, the boilers are refilled with fresh water; this washing is also evaporated, the result being that we have recovered about 75 per cent. of our soda which we used.

29828. That is a process which is remunerative?—Yes, it pays to recover that.

29829. You use it again?—We use it all over again. If that recovery were increased to any very large extent, it would become very expensive and troublesome.

29830. Then what becomes of the part of it from which it does not pay to extract the soda?—The washings are trickled into our effluent, and pass away in our effluent by degrees.

29831. Do you take that part of the effluent and mix it with the effluents from other processes in your works, or do you deal with it separately?—It all goes together; it is all one; there is no separation.

29832. Then what do you do; how do you deal with it?—It goes into a tank, and then trickles into the effluent by degrees through a small pipe.

29833. You mean this portion from the recovery of soda?—The washings?

29834. The washings?—I am speaking of the washings now. Are you asking about what is recovered?

29835. No, I am asking how you deal with the residuum.—Which is not recovered?

29836. And I understood you to say that it simply flows with other liquors from other processes into a tank?—Into a tank.

29837. Then how do you deal with the mixed liquor?—Before it gets to the effluent it goes to a tank, and it trickles slowly into the effluent through that tank.

29838. Is there any process in connection with that?—None at all.

29839. It is simply a tank to give a regular flow?—The tank is used so that the waste liquor shall not come in suddenly with a rush.

29840. To cause a regular flow?—Yes.

29841. It flows into the general effluent?—Into the general effluent.

29842. How do you deal, if at all, with the general effluent?—The general effluent is not dealt with at all, except in so far as as much as possible is recovered and used over again before getting to the effluent. All our processes are dealt with before reaching the effluent; there is no treatment of the effluent after it becomes an effluent. The whole of the recovery is before it becomes an effluent. Take the machines; we have save-alls to each machine, and as far as possible all the liquid from these machines is caught and used over again. It is never allowed to get into the effluent. We do not treat the effluent by itself separately.

29843. You economise in all your various processes, as far as possible recovering material, using liquor over again and so forth, and in the end you have a certain effluent as a residuum. And I think you say you do not treat that effluent; that it flows into the river?—That is right.

29844. Now, what is the character of that effluent?

29845. (*Sir William Ramsay*). Is it turbid?—It is turbid, yes.

29846. (*Colonel Harding*). May I ask you this question? I will leave you to answer it in such way as you think safe. What is generally the character of your effluent; is it turbid, is it loaded with suspended matter, is it alkaline or is it acid, or what is the special feature of it?—Perhaps it will be sufficient if I say what would be found in the effluent and what the total amount of it is. May I put it in that way?

29847. Yes, it would be interesting for us to know what is the volume of the effluent, for instance, to begin with. The volume is a large one, is it not?—The volume is a large one; the minimum is 7,000 cubic feet a minute.

29848. And I think you work that out to represent about 58,000,000 cubic feet a week?—Yes, per working week.

29849. Well, we may take it that the effluent is of very large volume?—There is a very large volume of effluent, the minimum amounting to about 7,000 cubic feet a minute, and I may perhaps just say this, that the solid matter in the effluent is increased not more than 2 or 3 per 100,000. In the water which passes through our works, the total solids are not increased by more than from 2 to 3 per 100,000 by weight.

29850. Do you draw from the river for your supply?—Direct, yes.

29851. And I understand when you return it to the river, so far as suspended solids are concerned, the amount is not very largely increased?—A very small increase.

29852. You have the good fortune of a stream of very large volume passing your works?—Very large indeed.

29853. And although the volume of your effluent is in itself large, it is relatively small in comparison with that of the stream?—Quite so. The total flow of the river over a period of about 18 months is attached: you will see sometimes the river is very large indeed; the number of days on which it is small is very few indeed.

29854. Then you would probably claim, would you not that in a case like yours, where your effluent is very largely diluted, that you ought not to be called upon to purify to an extent beyond what may be necessary to prevent nuisance in the stream? Is that your view?—That is our view.

29855. Would you tell us what you think ought to be done in regard to standards? Do you think that in connection with a particular trade, such as the paper trade, it would be well for this Commission or any of the supervising authorities to suggest a standard applicable to your trade, and applicable to every manufacturer in that trade, or do you think that the standard ought to be a variable one, or do you think there ought not to be a standard at all?—I think there ought to be varying standards.

29856. Variable in relation to what—to the circumstances of the manufacturer?—In relation to the size of the river on which the mill is situated, the number of mills upon the river, the nature of the trade effluent, and how far the river is utilised for sewage purposes, as a general conveyor of sewage. I mean it is possible that a small mill might be on a river which is largely used in carrying sewage to the sea, if that were a pure stream it would be desirable to purify, but if that stream were used as a sewer it does no possible harm to the water at all.

29857. Then your view is that the volume and condition of the stream itself ought to be taken into account?—I think so. Let me put it in this way. On the river Don the amount of sewage which goes into that river is very considerable, and any pollution caused by a mill, a fine

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paper mill, is insignificant compared with the amount of sewage that goes into the river.

29858. And any authority which is looking after the pollution of the stream would put the same pressure upon authorities turning in sewage that it would on manufacturers turning in trade effluents, or should do so?—I suppose that is the case.

29859. Do you think the standard ought to be an elastic one in regard to the several manufacturers in a given trade; that one manufacturer may have facilities for purifying his effluent, while another may not? For instance, one may have abundant land, and another may have only just room to carry out his process.—That is a most important fact.

29860. But would it be fair to all manufacturers in a given trade that the same standard should apply to them all?—Well, I cannot help feeling that the circumstances of the case should be taken into consideration. For instance, if you have an effluent passing into a very large river, it could do no possible harm to that river, whereas the same effluent passing into a very small stream might injure that stream.

29861. Then you think the more important point in regard to the elasticity of the standard is the volume and condition of the stream, rather than the special conditions of the manufacturer?—I think it is, especially looking at it from a public point of view, the size of the stream and the number of mills upon the river, and more especially the nature of the trade effluent. If some of these possible sources of pollution in a mill like ours were to go into the river in small quantities it would do an infinite amount of damage.

29862. Evidently if a standard of that kind were fixed, it must only be a provisional standard, because the circumstances may change with the development of the industry in a given neighbourhood?—I think so.

29863. That whereas you suggest it might be possible to allow a small effluent to pass into a river, it might not be allowable to let ten manufactories be erected alongside each other passing a similar quantity of effluent?—Certainly; it might be quite right to allow one or two to pass an effluent into the river, whereas a hundred would certainly injure the river.

29864. Then on the whole, the only matter which you think should affect a standard, if a standard were set up for each trade, is the condition of the stream itself?—And the nature of the trade effluent, and also the nature of the treated effluent.

29865. Then in the paper trade, for instance, does the character of the effluent vary very widely? I suppose it does in certain common kinds of paper?—Oh, very greatly; it is very much worse in some than others. I know that many years ago a very large amount of pollution went on in many mills which never takes place now. I believe in our own mill pollution took place twenty or thirty years ago which never takes place now.

29866. Why?—Because we have improved all our processes enormously.

29867. Has that been due in any way to pressure from the outside riparian owners or Rivers Authorities?—No, I think partly the desire of the Company to follow the law—to keep as close to the law as possible—and in certain cases it pays to do so. As regards recovery of soda, it pays to do so; as regards recovery of lime from manufacturers' refuse it has been our desire to make the effluent such that nobody could attack us.

29868. Then you say in the paper trade it has generally paid not to waste materials?—Not to waste soda, but it does not pay to prevent pollution so far as lime is concerned at all.

29869. Now, would it, in your opinion, be practicable, not only in the paper trade but for any trade, to prescribe a simple standard which would, for instance, limit the suspended matter, and insist upon an effluent being neutral within certain limits? Would that be practicable; would it be fair to all manufacturers?—It is a difficult question to answer. I can only speak for my own case; I do not know the circumstances of other paper manufacturers. It would not be fair to answer for other people.

29870. Then I pass on. Suppose in your case that you had not a stream of considerable volume flowing by you, but a comparatively small stream, would it be possible for you to carry out processes in connection with your effluent to purify it considerably beyond the point which is now reached?—If the law made it necessary for us to increase our purification very largely, it would entail very great expense. We are in a narrow hollow; we are very cramped for room. We recently had to increase our power; we recently had to put down electric plant because we had no room to put down boilers and engines in their proper place. We had to put up the buildings to one side. It would certainly enormously increase the expense of our works if we had to purify more than we do now.

29871. It would be possible for you to lift it by pumping to a more suitable site in the neighbourhood, would it not?—At very great expense.

29872. Do you think that that expense would be prohibitive?—Well, probably. I might put it in this way, that the handicap of the British manufacturer now in every direction is so great, that every additional load put on makes the weight more difficult to bear.

29873. One appreciates that, but you see what I was wanting to get at was this. In your case you have the advantage of large dilution, and you claim that in view of that large dilution it is not necessary for you to purify the effluents beyond the point at which you now turn them out?—Yes.

29874. But I am asking, in the case of a similar manufacturer being placed in a position where there was comparatively small dilution by the stream, how far in your opinion it would be practicable for him to purify the effluent to a higher degree?—If an effluent such as comes from our mill was on a very small stream, you ask whether it would be practicable to purify to a higher degree?

29875. Practicable from a financial point of view?—It would be possible, and if the stream were in a flat country the expense would not be so great.

29876. You think it would be possible?—It would be possible in a flat country, but in a narrow valley, with rising ground all round, it could not be done except at very great expense.

29877. So it is quite possible that manufacturers may be so placed that the insistence on a higher degree of purification might be ruinous?—I believe there are certain cases in which, if very strict purification were insisted upon, it would mean the closing of the mill. I believe there are such cases existing.

29878. You probably have a considerable acquaintance with foreign paper manufacturers, have you not?—Not very great.

29879. Do you happen to know, say in Germany, whether any pressure is put upon large paper mills to purify their effluents?—I am afraid any evidence I may give is only by hearsay. I am told it varies very much in different parts of Germany. In some places there is practically no pressure.

29880. And in others?—In others a certain amount of pressure is exerted, but to what extent I am unable to say.

29881. You are not able to say as to results?—No, I am not able to say; my information is only hearsay.

29882. Have you anything to say to us in regard to alteration of the law as to preventing rivers pollution, which you think would be worthy of our attention?—In our opinion, no alteration of the law is necessary.

29883. Well, your circumstances are somewhat easy where you are placed, but there are cases where Rivers Boards and Local Authorities are bringing considerable pressure upon manufacturers, and I take it that your answer is that these things have not affected yourself or your firm so much, and you have not given them attention?—We have not given them attention. The only thing I might say is this, with reference to the question you ask me; if any alteration were to take place at all, I do think it should be done in the direction of having different standards suitable to the circumstances of the case, and, if necessary, enforced by an outside authority altogether, who can judge fairly between the manufacturer and the other people who are concerned.

29884. Would you consider that an authority dealing with a watershed, a Rivers Board, would be a suitable authority ?—It depends entirely on how the Board is constituted. I can understand if a Board were constituted of landowners, who had no interest in the manufacturer, it would not be fair; or if the Board were composed of manufacturers it would not be fair, and the difficulty of course is to find an authority which is absolutely unbiassed.

29885. Well, you have as an example the Rivers Boards of Lancashire and Yorkshire, and they deal with large areas, and are constituted by nominees from the County Authorities and from the County Boroughs, and you therefore have representatives there ranging over a variety of interests ?—I have no experience of the working of those Boards.

29886. All you say to us is that in your opinion these matters should not be controlled by a mere local authority? —Certainly.

29887. But that it should be an authority representative of a wider area ?—Certainly.

29888. And of mixed interests ?—Mixed interests, certainly. It would not be right to lay the expenses of a board on ratepayers unless really necessary.

29889. (*Sir William Ramsay*). Might I just ask you a few questions about the method of disposal of your refuse. I suppose you recover a good deal by means of these gauze filters, this recovering plant ? You recover a good deal of the pulp ?—Yes.

29890. And what chiefly runs through is the china clay I fancy, and the very finely divided pulp which cannot be retained ?—Yes, that is the case.

29891. Does anything happen to it except settling ?—No.

29892. Do you precipitate in any way ?—No.

29893. Not in the tanks ?—No.

29894. How long does the liquor stay in the tanks before discharge ? Is it a continuous discharge ?—It is a continuous discharge.

29895. It is admitted at the bottom and let out at the top, or something of that kind ?—The liquor from the soda is let in at the top and goes out at the bottom, but the other effluents do not go into a tank at all.

29896. Oh, you do not mix them all ?—No, only the soda goes into that tank.

29897. And the others do not have any chance of settling ?—Except in a level cut below. There is a level canal between our works and the river about 400 yards long.

29898. It has been suggested to us that by the addition of a little alumina, in fact there is alumina, is there not, connected with the sizing of the paper ?—There is; yes.

29899. Would it not be an advantage to keep that alumina, and so carry down finely suspended matters ?—Precipitate the alumina ?

29900. Precipitate the alumina. It will then carry down along with itself such finely suspended fibrous matters ?—By the addition of lime ?

29901. By entanglement. We have been informed that that gives good results ?—You see, one of the troubles with effluents is the solid matter which is carried down which may deposit in the river, and if it contains size, that is to say decomposable animal matter, it will putrefy somewhere or another. Well, that would be very largely removed by some precipitation process such as I have suggested ?—I have no doubt it could.

29903. And I suppose at very small expense. Would it mean putting down more tanks ?—It would be very expensive for a mill situated such as the one I am speaking of.

29904. Owing to want of room ?—Partly owing to want of room. The system of purification in a mill like this has been to recover and purify every petty effluent before it ever reaches the main effluent. It would be most difficult, and almost impossible to combine all our petty effluents into one for treatment.

29905. You could not lead all your petty effluents into one tank ?—Into one tank ? It would be an enormous expense. The works cover a very large area, and all these petty effluents have different means of access to the main effluent, which is a large body of fresh water practically.

29906. Then how do you dispose of the lime which is the refuse after causticising your soda ?—This is a small effluent, treated separately, it goes to settling tanks. There it settles, and the liquor is pumped back and used over again, and the lime is put upon carts, and carted away about three quarters of a mile.

29907. Do you require to cart it so far ?—Yes; at the present moment the carting away of our waste costs a very large sum of money, probably several hundreds of pounds a year.

29908. And then the refuse of the bleaching material and bleaching powder ?—That is treated in exactly the same way. This dilute waste all runs down after the several waters are taken off to a settling tank, the liquor is pumped back and is used over again and the lime is all carted away.

29909. To the same distance ?—To the same place, and there it mixes with the refuse from the boilers, ashes, danders, and the like; they are all mixed together.

29910. Do you make many coloured papers ?—A certain amount, not very much.

29911. Is there any trouble with the colouring matter ; is the effluent coloured ?—No doubt for a short time it does colour the water, but not to a large extent. The colour is very distinct where it comes out into the effluent but by the time it gets into the river the colour is mixed up and it is almost *nil*, hardly visible.

29912. You do not make any wood pulp paper, do you; do you buy your pulp ?—We buy a certain amount of pulp; we do not use very much pulp.

29913. You do not make it ?—We make none. I think you asked me whether there was not some chance, or alluded to the possibility, of fibre and such-like matter putrefying. We have tested our effluent in that way very carefully and we have never found any traces of putrefaction.

29914. Of course, there is very little indeed ?—It has been in stoppered bottles at a temperature of from 70 to 80 degrees, I think it was, and kept for several days, and on the stopper being removed there was not a vestige or a trace of smell or putrefaction.

29915. It is very dilute, of course. The effluent you turn out is slightly alkaline owing to the caustic soda washings ?—Slightly; I have not a sufficient knowledge of chemistry to say what is the general unit, or the measure of alkalinity, but when tested the river above the mill was found to be alkaline.

29916. Owing to the carbonate of lime, no doubt ?—A chemist who once examined our water informed us that the alkalinity of the Don water was about 4 and of our effluent about 5; I do not know what his unit was.

29917. Grains per gallon probably, perhaps. Would it be possible for you to give us any notion of the capital sum you have spent in putting up such purification works as you have had, and of the annual cost of running, or is that a question you would rather not answer ?—I would try and get the information; I cannot answer offhand. I should think that probably our purification now costs us considerably over £1,000 a year.

29918. In interest on plant and in actual expenses ?—I mean in actual expenses.

29919. Not including interest on plant ?—I should think so, but I have not any figures to verify it by.

29920. (*Sir William Power.*) Is that allowing for the recovery of the soda ?—I am putting that to one side; I am not counting that. If you consider the amount of carting. We have to cart this enormous mass of stuff to a very considerable distance; it is nearly all in carting. We considered the question of putting up a wire tramway to carry it all away, but, of course, the difficulty would be handling the waste on the waste heap, carts can be tipped here or there as may be required to level the waste heap, whereas with a railway the point of delivery is fixed.

29921. Only one more question. Do you consider yourselves at a disadvantage compared with any other paper-makers on the same river, or are you treated fairly as a whole ?—At the present moment ?

29922. At the present moment. I understand the only pressure that can be put on is by threatened action by riparian proprietors. That is the only pressure you have

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to fear, I daresay ?—Perhaps it would not be out of the way to say what has happened.

29923. I should like to know, yes ?—Some years ago we knew that we were being attacked for pollution. In our opinion we were not polluting the river. We are the very largest people on the River Don, and being very large and bulking very largely in the public eye, every iniquity in the River Don is put down to us. I went down to Lancashire where a gentleman who is present here was kind enough to show me what was being done on some of the rivers in Lancashire, I came back again and came to the conclusion that we were not in any sense of the word polluting. A meeting was arranged between ourselves and the County Council after some discussion, we agreed to pay half the cost of an outside expert who should come in and report upon us without in any way prejudicing our rights or our wrongs in any way. A gentleman was chosen, a well-known gentleman in Scotland, Mr. Curphey, who is, I believe, the chemist to the Secretary for Scotland. He came down. Two stipulations were made, one, that all the other mills should be examined at the same time, and secondly, if we required samples of the water that he tested, we should have them also. The report was made. I have never seen the report upon the other mills ; if was withheld from us, but I believe they have all had to do something ; with regard to our mill the examiner said he was not prepared to recommend that anything should be done more than was being done.

29924. Why was this report asked for ; because of any external pressure ?—The external pressure was brought to bear upon the County Council, so I am led to believe—there again I only speak from hearsay—by the riparian owners, the fishery owners.

29925. And do they profess themselves satisfied with that report ?—I have no means of judging.

29926. At any rate you have not had to do anything ?—We have not had to do anything. We were practically told we were doing all that was right.

29927. Then I suppose you feel yourselves in a superior position to the other manufacturers ; at all events, you have nothing to complain of there ?—I think the outside authority, the gentleman in whom both parties had trust, recognised that we were doing our very best, and that it was the object of my firm to do our very best and what is right, but we do think there are certain people who ask for impossibilities.

29928. (*Mr. Tatton.*) Can you give us any idea of the volume of water that actually passes through your mill ; I do not mean to say the power water, but what you use in your various processes. I mean to say what volume would have to be treated suppose you had to pass it through a tank ?—I cannot give you that.

29929. The figure you give us here is the power water ?—It is all mixed together ; it is all treated as one.

29930. Would it require a very large space. You say you are closed in a good deal at your mills, so that you would find great difficulty in finding room to treat your waste ?—We should have great difficulty in doing that, and we should have the expense of the continuous pumping.

29931. Yes, you would have that ?—In connection with that very question you ask, there are certain mills which are situated at pit mouth ; to them coal is absolutely nothing at all. This large business has been developed on the River Don owing to water power. It is a long way from coal fields, the whole of our coal has to come from Northumberland at a very great expense, and the price of coal has been steadily rising for the last eight or ten years, and the expense of coal is becoming a most serious matter, and therefore you will understand that our desire is to reduce power to the very smallest limit possible.

29932. Yes, that is the difficulty ?—That is our difficulty. And also the space and the place for settling tanks. We only have one small space left now in which we have room for extensions of our mill. If that were covered we should have to pump, I suppose, 80 or 90 feet.

29933. Could you not take it below your mill ?—No, because below the mill on our side of the river the land rises all round us. In front we cannot even get a railway into our works ; it is cheaper for us to cart our stuff all the way to Aberdeen than it is to bring a railway into our works. The railway company have schemes but they cannot compete with the carting on account of the very heavy gradients. We should perhaps have to make our settling tank possibly three-quarters of a mile away.

29934. Above your works ?—Above our works ; that is where we cart all our refuse to now. We have no place to cart our refuse to except on to a heap three-quarters of a mile away.

29935. You do not think it is fair to ask a man to pump, placed as you are ?—I think it would be very unfair to ask us to pump.

29936. Of course, many of them do, as you know ?—Yes, I know it is done. Of course, I quite understand if a business is a menace to the health of a community it is better shut up altogether. That is an extremity, I suppose, which might have to be faced by some mills in the case of a business like ours, which we consider is doing no possible harm to the river, we think it would be a very great hardship to ask us to pump.

29937. However, in your case, it is a matter of the volume of the river you turn into ?—Yes.

29938. That is your contention ?—Yes.

29939. (*Sir William Ramsay.*) On the other hand, it is a river which it is essential to keep especially pure, because it is a very large salmon river, is it not ?—Yes, it is, but no damage, so far as I know, has ever been done to any salmon in the river. We have had considerable experience of it. I have been there for fifteen years now and I have seen the river full of salmon and none of them any the worse for it.

29940. (*Mr. Tatton.*) Supposing it happened that other works were started on that river and it got bad ?—I can conceive that if there was a possibility of a large number of works being started upon the river something might have to be done ; but there is not the slightest chance of anybody putting up any works there ; it is out of the question. I mean to say, if only our Company could recover a part of their capital they would be only too thankful to leave. I mean there is an enormous capital vested there, put down into this valley. Our capital is something like nearly £1,000,000, all laid down there and the margin of profits is getting smaller and smaller. In the statement I have produced here you will see what the tendency is ; what a struggle the British manufacturer has to keep his head above water, as compared with the foreigner who imports the paper into this country. These imports are increasing by leaps and bounds and our exports are not increasing in that way.

29941. (*Chairman.*) Is the Don used for drinking purposes at all ?—Not at all ; no. The town of Aberdeen gets its water supply now from near the source of the Dee, and they have in contemplation, going still further to the Avon, over the next watershed to bring their water from there. Whether that scheme will ever come on or not I cannot say. The district in which we and all our workers live, get their water supply from springs on the other side of the river. and it is carried through water pipes over the river to a reservoir and it supplies the whole district.

29942. Then higher up I suppose the waters of the Don must be fit for drinking. It flows through a good bit of agricultural land ?—Yes, there are two or three small towns on it.

29943. Do they get their water from it ?—Certainly one, Inverurie, has recently put up fresh water works. I cannot speak for any other town or village, but speaking generally, I should say nobody uses the water of the Don within many miles of us.

29944. But after it has got once below you, nobody thinks of using it for drinking purposes ?—No. Immediately below our works a flow of sewage goes into the river and other sewage flows in at different places between us and the sea.

29945. (*Mr. Stafford.*) The Don at Stoneywood is a great swift river, is it not ?—Very swift.

29946. Are there many paper manufacturers on the Don ?—There is one above us, some eight or ten miles above us, and there are two below us.

29947. Are there any other factories ?—Well there are four ; that four includes other manufactories ; there was another woollen manufacturer; they have stopped altogether; one woollen manufacturer still continues.

29948. And there are three paper manufacturers as well as yourselves?—Yes, on the whole river.

29949. Are they doing more or less than you are in the way of purification?—I do not know at those works what they are doing, I cannot speak with authority; I understand they were called upon to improve their effluents, and I think they have done so.

29950. By whom?—This outside expert who came down I suppose reported unfavourably of them. This is only hearsay, because I never saw the Reports.

29951. On the part of the riparian owners?—No, the County Council.

29952. The County Council, on account of the pollution of the river?—Yes.

29953. Then it was a public health matter more than a question of the destruction of fish, was it?—Well, I cannot tell you what the object was; all I can say is the County Council took the matter up.

29954. The riparian owners did not interfere; they did not think that the fish were being destroyed?—I do not know what action the riparian owners took; so far as I know they took none. I cannot say what intercourse they had with the County Council; I do not know.

29955. Then it was the County Council who called upon them to treat their sewage?—Yes.

29956. Their refuse?—Yes, I am told they did so.

29957. You do not know what they are doing?—No; I am told they have done what they were asked to do.

29958. You do not know whether that is more or less than you were doing?—I do not know.

29959. Less than you were doing?—I suppose less than we were doing before the improvements took place.

29960. You are only taking out the soda; you are not doing more than that?—Yes, we are taking out the soda, we are taking out the caustic lime, we are taking out the bleach lime, and all the dusting.

29961. All of which are paying?—No, excuse me, lime does not pay, the caustic lime does not pay, the dusting does not pay, the bleach lime does not pay.

29962. Does the taking out of the soda pay for taking out all these other things?—No, I do not think so.

29963. You are very strong upon having different standards, but now, between manufacturers, manufacturers of the same thing, say manufacturers of paper, do you think it is fair to have different standards; would it not be handicapping some of the manufacturers unfairly?—Well, may I put it in this way? Take a manufacturer who has got his mill at pit mouth, and who has got an unlimited quantity of coal at cheap price, it would not be a very great hardship to ask him who has the advantage of coal, cheap coal close at hand. If you have another manufacturer, on a large river, and very dear coal, it is rather hard to take away what little advantage he has. You cannot put him upon an equality as regards coal; is it not a little hard to put him to do more than is necessary for his own river.

29964. You are only asking a man to do something to purify the river and in that way, to keep the river pure, must you not ask that from everybody? If you do not do that with everybody how can you make one manufacturer do something which you do not ask another manufacturer to do; is not that handicapping him in his trade?—It is handicapping a manufacturer to ask him to do more than is necessary for his own river.

29965. A man who is asked to do more?—A man who is asked to do more.

29966. If you have different standards one class of men must be asked to do more than another; is that fair to the man who is asked to do more?—Is not the question rather what is unfair. It may seem perhaps unfair that one man should have the advantage of good coal and the other has not.

29967. That is the chance of position; it has nothing to do with the purity of the river?—Is it not also the fact that the chance of position gives a man the advantage of a large river instead of a small stream?

29968. Quite so?—Is it right to deprive him of having the advantage of the large stream?

29969. You are not depriving him of anything; you are only saying there should be one standard for the whole river, or one standard for the whole trade. You want to have different standards and if you have different standards it seems to me you are likely to handicap one manufacturer and put him at a disadvantage with another in the same trade. It is only because you are so very strong about the point of different standards that I thought there might be a possible objection?—If it is the interest of the community, the interest of the community must, of course, take precedence, I grant that, but if it does no harm to the community to pollute to a very small solid, is it not unfair to insist on doing more than is necessary and thereby destroy natural advantages of a particular site. To equalise the conditions of all manufacturers is not possible.

29970. (*Sir William Ramsay*). Might I just ask one or two questions? Have you examined the sludges that are put on the land to see if they could be of any practical use?—The soda-lime has been experimented with for many years to try to use it for making cement. I believe that a more or less successful cement is possible, but the expense is so great that it has been dropped altogether. The experiments were carried out I believe by certain paper makers in the South of Scotland.

29971. It is no use for agricultural purposes, the lime that is put on the land?—We have tried to get farmers to take it but they will not touch it.

29972. They will not take it?—We have tried to do that; I cannot say whether rightly or wrongly, they leave it alone.

29973. (*Chairman*). Thank you very much.

NINETY-FIFTH DAY.

Tuesday, 26th October, 1909.

PRESENT:

The Rt. Hon. The Earl of Iddesleigh (*Chairman*) (*presiding*).
Colonel T. W. Harding, J.P., D.L.
Sir William Ramsay, K.C.B., F.R.S.
Sir William H. Power, K.C.B., F.R.S.
Mr. T. J. Stafford, C.B., F.R.C.S.I.
Mr. R. A. Tatton, M.Inst.C.E.
Mr. F. J. Willis (*Secretary*).

ALSO PRESENT:

Dr. A. C. Houston.
Dr. George McGowan.
Mr. C. C. Frye.
Mr. G. B. Kershaw.

Mr. John H. Hanson, and Mr. John Haigh, Members of the firm of Abbey & Hanson, Engineers to the West Riding of Yorkshire Mill-Owners' and Occupiers' Association; and Mr. Thorp Whitaker, of the Bradford Dyers' Association, Ltd., recalled; and further Examined.

Mr. John H. Hanson, Mr. John Haigh, and Mr. Thorp Whitaker.

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29974. (*Chairman.*) Colonel Harding will take your Examination-in-Chief.

29975. (*Colonel Harding.*) You gentlemen are coming before us to-day representing the West Riding of Yorkshire Mill-Owners' and Occupiers' Association?—(*Mr. Hanson.*) Yes, Sir.

29976. And we had the advantage some months ago of having some evidence from your Association in regard to the difficulties of manufacturers, and to the work which your Association has accomplished in bringing about certain agreements between manufacturers and important Local Authorities?—Yes, Sir.

29977. Agreements which, I believe, have been embodied in certain Acts of Parliament?—They have.

29978. And we gathered that your Association, as such, had not promoted any experiments at the joint expense of their members for the purpose of finding the best way of solving the difficulties before you?—That is so.

29979. But I think it was rather foreshadowed that possibly your Association might, at a later stage, undertake work of the kind, or at all events, assist in work of the kind?—I think that question was raised, but the position I then put before the Commission was that the traders would not feel justified in expending money in the direction you have indicated; that they were quite willing to prepare such documents as are before you this morning, but beyond that they would not feel justified in providing money for such experiments. I want to make that quite clear. I think I should also add that Mr. Thorp Whitaker appears here as specially representing the Bradford Dyers' Association, who are also members of the West Riding Association.

29980. Then when you were before us last you promised to send us, in the course of this month, analyses of various polluting liquors, and of the results obtained by treatment at different works. You have now done so in the valuable table which lies before us to-day, and we are grateful to you for having put it in the form desired by our chemist, Dr. McGowan. Now these examples that you put before us resolve themselves into two classes—one in regard to effluents passing into sewers, and the other in regard to effluents passing into streams?—That is so.*

29981. Now the first three examples that you give us in the table relate to effluents passing into sewers?—Yes

29982. Of course, in those cases the difficulty is enormously reduced, because it is not aimed to get an effluent of very high class. The Local Authority will be satisfied probably if the amount of suspended matters is considerably reduced, and if any excess in acidity is removed. Is not that so?—That is so

29983. Now we find that the first three examples you give very largely reduce the suspended matter, and we know that the suspended matter in the crude liquors from these woollen works is very high indeed?—Yes.

29984. In the first example you give I see it is put at 1,752 parts of suspended matter per 100,000, and that by treatment has been reduced to 9·6?—That is so.

29985. And that I take it is satisfactory to the Local Authority in question?—We have no reason to think otherwise, and I might point out that the large quantity of suspended matter there is due in the first two cases to Fuller's earth.

29986. Then it will probably be better for us to confine our attention to those cases where the effluent flows to streams?—Very well.

29987. The whole of the data that you have given us in these tables refers, of course, to various branches of the wool trade?—Yes, the woollen and worsted trade, and in dividing them under these heads we have done so not with the idea that this was a kind of classification which you would be likely to adopt, but in order to separate them as far as it is possible to separate them, to give you an opportunity to judge which might be put together under any particular class.

29988. Now, speaking generally, the manufacturers in the first instance endeavoured to remove from their waste waters the grease that is recoverable?—That is so.

29989. And that is done in so-called seak-tanks?—Yes.

29990. And when the grease has been removed the effluent from those seak-tanks is usually a very acid output?—It is.

29991. And there is usually a considerable amount of fatty matter remaining?—Yes.

29992. No. 4 is a plant which I think we have some experience of; Waite's apparatus?—Waite's apparatus.

29993. That is just simply a settling apparatus?—That is so.

29994. And what is the precipitant used?—Perhaps it will be as well if Mr. Haigh explained exactly what is done at those particular works.

29995. We have had before us Waite's apparatus?—You have seen this identical plant.

29996. We know it consists of certain vertical cylinders in which settlement takes place?—(*Mr. Haigh.*) Settlement and upward filtration; both precipitation and upward filtration.

29997. What is the precipitant used?—Lime in this case, and alumina ferric.

29998. I observe that the precipitation is effective: the amount of suspended matter is very well reduced?—Yes.

29999. The alkalinity is not serious?—No.

30000. The hardness is excessive?—In spite of that they use it for their boilers. This plant discharges into a large cistern on the roof of some of their buildings adjoining the plant, where of course it mixes with rainwater which falls into this open tank, and from that tank they use the water for their boilers, and for other trade purposes.

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* See Tables of Analyses at end of evidence.

30001. This characteristic and excessive hardness of the effluents seems to be common to a great number of the effluents noted in these tables ?—(*Mr. Hanson.*) It is.

30002. Has any attempt been made to overcome that difficulty, might I ask ? For instance, is the hardness mostly of a temporary or of a permanent character ?—(*Mr. Whitaker.*) It will be mostly permanent if it is from an acid effluent (*Mr. Haigh.*) If it is from an acid effluent it will be mostly permanent; if it is due to the presence of an excess of lime it is more temporary.

30003. Then has anything been done with a view to endeavouring to minimise this excessive hardness ?—Well, I should just like to read you a note with reference to hardness, and to preface that note by saying that the trader up to the present having no fixed standard to aim at, has had to aim as near as he can at the standard imagined by the Rivers Board, which means a clear pure-looking effluent, free from acid and alkalinity and colour, but of which the hardness has not been considered of so much importance. You will note from the analytical data that the hardness of the treated effluent is invariably very high, and this is due (*a*) to the excess of lime which must be used to produce a clear, good coloured effluent, containing but a small amount of suspended matter; (*b*) to the excess of acid used in cracking the soap suds from piece and wool scouring departments. In this connection we would point out that to obtain an effluent free from fatty matter a slight excess of acid is necessary and on the practical scale, it cannot be expected that a workman will be able to distinguish between an excess of 0·1 to 0·2 per cent. The difference of 0·2 per cent. however, will represent in soap destroying properties no less than 200° of hardness per 100,000. We are quite aware that this effluent will be mixed with the dye-house effluent and the hardness (soap destroying) will be proportionately reduced. The lime and alumina ferric used upon the mixed effluent to remove the colour and matter in suspension is also used in excess in order to obtain a good coloured effluent, and this also tends to appreciably increase the final hardness. Little wonder therefore that the hardness of the treated effluent is often 100° or more. The hardness of the treated effluent could be considerably reduced (this is a point I wish to call your attention to particularly) were the demands as regards colour of the effluent and matter in suspension a little less stringent, and it is obvious that works lower down the stream would prefer a slightly coloured, softer water to one which was clear, but contained large quantities of lime and alumina ferric.

A more liberal interpretation of the colour standard is what we consider desirable in the interests of the users of the water lower down the stream.

30004. I gather from what you say that the inspecting authorities, that is, the Rivers Board, aim rather at reducing suspended matter ?—Yes.

30005. Alkalinity and acidity, and then hardness ?—Yes, I think they do.

30006. But the excessive hardness of effluents is bound to be very deleterious, is it not, to the use of the water ?—It makes it a much more expensive water to use by people who have to use soap with it lower down the stream.

30007. Is there any practical means of reducing this hardness by a further process, beyond those of which you give us the results ?—Well, beyond not putting in so much——

30008. No; assuming you have obtained a fair result in regard to suspended matter, and you have brought your effluent into fair condition in regard to alkalinity or acidity, but that you have done so at the expense of hardness, is there any further process which would enable you then to reduce the hardness within practical limits of cost ?—I do not know of any.

30009. (*Sir William Ramsay.*) Might I interpose here, and ask, do you know how the hardness is determined, by applying the usual soap test ?—Yes.

30010. Then that would count as excess of acid ?—Yes, it would.

30011. Do you also count as hardness sulphate of lime, permanent hardness, and temporary hardness ?—All three.

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30012. Is your effluent distinctly acid ?—No, not in all cases.

30013. In some cases ?—In this case, no doubt, the hardness is due to the acidity.

30014. It pays to soften the water to 10 to 15 per cent. of hardness. Would it not pay either you or the proprietors of the works on the stream below you to soften that water ?—I take it that in a small stream, where an excess of hardness was put in high up the stream, the trader below would have to soften it before he could use the water.

30015. Do they actually soften it before they use it ?—They do in one or two cases in the River Calder. I know one case where they put down one of these Waite's plants for the purpose of softening the water for their own use.

30016. They do not expect you to do that ?—The trader does that on his own; they either use more soap, or they soften the water.

30017–8. (*Colonel Harding.*) In Case No. 5, I notice there that the effluent still contains a large amount of suspended matter ?—Yes.

30019. And that the alkalinity is high ?—(*Mr. Haigh.*) These works have two processes, as most of them have; a piece-scouring which is treated in the seak tanks, and which I believe is treated very satisfactorily, and the dye waters which are not treated so satisfactorily.

30020. Are the dye waters mixed with the seak tank effluents ?—Yes, the seak tank effluents join the dye waters and are treated with lime, and that is the only precipitant that they have used up to the present, and the two are treated together in settling tanks and filter beds.

30021. I notice that you also mention that filters are used. To what extent ?—The filters are small and not very efficient, and I think it is probably largely due to this that so much solid in suspension finds its way into the effluent.

30022. Then it is practically rough sedimentation ?—The solids in suspension are practically sediment which should have been arrested by the filter.

30023. You would probably admit that in a case like this further improvement can be attained ?—Oh; most decidedly; yes. (*Mr. Hanson.*) Take the column next to the cost of the plant, and you will get there the area of the filter beds, which in this case is only 181 square yards.

30024. Well, it is practically mere sedimentation ?—(*Mr. Haigh.*) That is to say, it requires further filtration. There the hardness you will notice is 70; that is due to the excess of lime with which they try to precipitate the acid seak effluent and the dye waters.

30025. This is a case where admittedly the results could be much improved ?—I think so, undoubtedly.

30026. Then in the case of No. 6, what is Mackey's plant used there ?—Well, Mackey's plant is a patent plant, it really is the filtration of the effluent by the sediment in itself. It is a boiler placed at an angle like that (indicating). The stuff comes in at the bottom and out at the top. In going through it is forced either by being pumped or by gravitation through its own sludge, so to speak, and filters itself, this causing a stirring up of the sediment in the hope that the heavy sediment will catch on to the light, and the whole be precipitated. The previous treatment is lime. It is necessary to have a large sump, in which to get a fairly average blend of the stuff which is turned out by the various processes in the mill, and from that it passes through the plant and then through a little wood fibre filter and so into the stream.

30027. Except for the excessive hardness of the result that effluent seems to be fair ?—Yes, and the excessive hardness is due to the excess of lime used to cause a clear, bright effluent.

30028–9. Now, in the next case, No. 7, there is used the plant of H. P. Watson, Ltd. Would you tell us briefly what that is ?—Well, that is settlement by precipitation and filtration; there is nothing really special about it.

30030. To what extent is there filtration ?—I have not got the particulars of that, but the plant is supposed by the patentee to be capable of treating 2,000 gallons per hour.

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30031. I suppose I may take it that that is again precipitation ?—Precipitation and filtration.

30032. Is the extent of filtration adequate ?—No, I should say it is not.

30033. We may look upon it practically as a precipitation plant ?—Yes, as a precipitation plant.

30034. In this case the hardness is beyond any of the examples we have yet dealt with—105 ?—Yes, they have a very hard water to deal with, and I do not think they soften it before they use it. I really cannot account for it being so high, except on that ground. There is the acidity in the effluent which may possibly account for it, but it is only slight.

30035. I notice that in this particular case the cost of treatment is quite nominal, when the cost has been credited with the amount of oil recovered ?—Yes.

30036. It is exceedingly small ?—Oh, yes, it is practically nil.

30037. Then would not more be possible in that case ?—Well, it is 1d.

30038. £18 15s. I see is the total cost for the year ?—Yes.

30039. It is trivial ?—Yes.

30040. Would it not be possible in a case like that, where a manufacturer has evidently as yet gone to very trifling expense for the purification of his waters, for him to carry out some process for reducing the excessive hardness ?—Yes, if he knew what to do and how to do it.

30041. In that case would it be permanent hardness ? I see it is slightly acid ?—I do not know whether it is permanent or temporary hardness.

30042. As a matter of fact, no experiments have been made by him ?—No, his plant has been down only a very short time. No doubt he will improve it.

30043. I do not know that I need go through all these cases. I see that in very few cases indeed can we look upon the result as thoroughly satisfactory, and, speaking generally, it consists of precipitation. Have you any case among these where anything like effective filtration has been carried out ?—Yes, I should say No. 16 you might take as being quite a first-rate plant, where both precipitation and filtration takes place.

30044. Which is that ?—No. 16. Where they have large seak tanks and large precipitation tanks. The acid effluent from the seak tanks flows into a sump, where it meets the dye waters, and the two are pumped up and treated in the precipitation tanks. The result I think you will consider is satisfactory.

30045. The alkalinity is small ; the hardness is not by any means so great as in the former cases.—No.

30046. The suspended matter is not very high ; not higher than it should be.—No.

30047. Then in regard to the filtration there, you were going to explain it to us.—Oh, there they have filters in addition to the precipitation.

30048. Well, what is the extent of the filters ?—320 square yards of filter beds.

30049. And how are they worked ?—The filter beds are situated underneath the settling tanks. They open a valve at the bottom and let the floating arm let out the clear water, trickle on to the filter underneath, fill the filter up, and let it find its way through.

30050. It is a streaming filter ?—It is a streaming filter.

30051. With intervals of rest ?—With intervals of rest.

30052. Do you find that the filtration much improves the effluent beyond what is accomplished by mere precipitation ?—Oh yes, I think it does.

30053. You think that filtration is worth carrying out ?—I do.

30054. You have not in your mind any figures in regard to the amount of improvement brought about by filtration in that case ?—No, I have no analysis ; it is simply a question of what one judges by looking at it without testing it.

30055. Then, speaking generally, you think that filtration following upon precipitation would give improved results ?—I do.

30056. And that it is practicable to carry it out ?—I do ; well, where they have room, of course.

30057. Now, in regard to the cost in that particular case, the cost that the people seem to have gone to is considerable, £2,482 ?—Yes.

30058. But that is an expenditure which has been incurred not primarily for the purpose of purification, but rather for purposes of recovery, is it not ?—Well, as a matter of fact the recovery is a very complete one, and therefore the cost is reduced substantially. It is less than ½d. per thousand gallons treated.

30059. Can a result of this kind be attained in other mills ?—Oh, in some trades, certainly.

30060. Because I find the cost per annum is reduced to a mere nominal one, £74 a year.—Yes ; of course, they do the complete treatment there. They extract their own grease, they charge themselves with the market price of the oil that they use ; and some they sell.

30061. Well, I take this as an example which seems to me to give fair results, and quite at a small cost. Now is not that practicable in all cases, or is there something special in the working of this firm which enables them to do what others cannot do ?—There is nothing special in the working of the firm, but of course it is not every firm that either has room to put down such a large plant, or could afford to put it down. (*Mr. Hanson.*) Or who could use their own by-products. (*Mr. Haigh.*) Yes.

30062. Then is the special circumstance of this firm that they are able to use the by-product of oil, and the others are not ?—They do so. I do not say that others would not be able to do it, others of the same class of trade. They would I suppose. (*Mr. Hanson.*) It depends on the quality of the oil, of course, that they want in the first instance, that they require for their business in the first instance. The quality of the oil which they get by this process is of course much inferior to the oil used in the mill in the first instance.

30063. (*Sir William Ramsay.*) But it would always sell, if they were selling it to outsiders ?—There is always a market for it, for their quality at the market price of course, but so far as the cost goes, I myself look upon this firm as quite exceptional, and generally I do not think that the same results could be obtained by any other firm, at any rate, that I know.

30064. (*Colonel Harding.*) Even if they went to the expense of such a plant ?—Well, there is another case. (*Mr. Haigh.*) No. 15. (*Mr. Hanson.*) No. 15 ; that is the next mill above, and very similar in volume. (*Mr. Haigh.*) Greater in volume. (*Mr. Hanson.*) It is 150,000 gallons a day, and there is an expenditure on plant of £2,900, with very large settling tanks, 240,000 gallons, 881 square yards of filter bed, and yet their cost you see is 2½d. as against ½d.

30065. And their results are by no means so good ?—By no means so good.

30066. Can you explain to us why ?—It is rather difficult.

30067. Is it that the area of settlement is inadequate or that they do not use the same or sufficient precipitant or what is it ?—(*Mr. Haigh.*) The difference is that in No. 15, so far as precipitation is concerned, they do not treat their acid effluent along with the dye waters ; the acid effluent joins the effluent from the dye water precipitation tanks and the two together pass through filters, but they do not go through any precipitation treatment together, as they do at No. 16. I believe that has largely affected the result. (*Mr. Hanson.*) That may affect the result.

30068. Let me ask you whether in your experience you consider it better to use a process of precipitation upon the mixed liquors, or upon the separate liquors ?—(*Mr. Haigh.*) Upon the mixed liquors, but it requires more tank accommodation, and is not, therefore, always possible. There may not be room for such a plant, but unquestionably, in my opinion, the best way to do it is to precipitate the mixed acid effluent from the seak tanks and the dye-water.

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30069. (*Sir William Ramsay.*) But that surely does not account for the great difference in net result. Whereas No. 16 has only to spend £74 a year, No. 15 has to spend £475, and yet the oil they recover, if sold in the open market, I suppose would bring the same price per ton ?—Well, there you see it comes to be a question whether No. 15 has made a good or a bad bargain with the man who takes his seak. In the case of No. 16 they take all their profits out by dealing with the thing themselves. In the other case there is a middle man who has a good bargain.

30070. Yes, I see.—(*Mr. Hanson.*) As you will see by the different amounts for seak plant, £50 in one case, the amount received for by-products, and in the other £750.

30071. Exactly.—And the smaller figure is the larger quantity.

30072. Quite !

30073. (*Mr. Tatton.*) No. 15 starts with an effluent which is five times as bad as No. 16 ?—Yes. (*Mr. Haigh.*) Yes, because they have a good deal more dyeing than the other people have.

30074. (*Colonel Harding.*) There may be something in management of the plant also, is there not ?—Oh, there is undoubtedly, and let me point out another thing as proving the advisability of treating these effluent altogether for precipitating the acid effluent and the dye effluent. When you treat them separately you have an excess in both cases, an excess of acidity in treating the seak water, and you have an excess of alumina ferric or whatever it is—lime—in treating the other. The two excesses together cause more trouble than if there was only one excess from the joint effluent.

30075. (*Sir William Ramsay.*) Before we pass on, may I make one other observation ? There is another difference one notices between Nos. 15 and 16 ; No. 15 spends only £485, whereas No. 16 spends £824. Is it not a case of judicious spending of capital ?—The amount expended by No. 16 includes all wages and materials for the complete treatment of their trade effluents. The amount expended by No. 15 does not include the wages and materials for the treatment of the seak, which are paid by the firm who rent the seak plant.

30076. (*Colonel Harding.*) That is exactly what I was saying, that the management of the plant is a most important point ?—Oh, a most important point.

30077. (*Sir William Ramsay.*) Does 15 know of the results that 16 obtains ?—I believe so, but unfortunately No. 15 has not a free hand at present.

30078. (*Colonel Harding.*) It seems to us that if it is possible in one case within reasonable limits of cost to obtain fair results, that the same might properly be expected to be carried out by others ?—Yes. (*Mr. Hanson.*) Yes, if the financial result also was the same.

30079. If the financial result is due to either mismanagement or bad construction of plant, then that is the fault of the individual manufacturer ?—Yes, and that is a commercial position which, of course, these traders all other things being equal, would remedy themselves.

30080. Would you look upon the case which we have just been considering, where the results obtained were fair, as one of the best examples to which you would like to call our attention—the case of No. 16 ?—(*Mr. Haigh.*) I do not think you could hope to get it better than that.

30081. Then you think that is a mill that we might properly visit ?—(*Mr. Hanson.*) Oh, it is, certainly. (*Mr. Haigh.*) Certainly, I should think that would be a very good one to visit. (*Mr. Hanson.*) There is another factor in connection with this which has not been brought into the financial part of this statement. In all these cases cost of site is excluded ; that is general to the whole of them. If the cost of site in this case, No. 16, was brought into account, it would very substantially alter this figure of 0.59 pence. They have had to utilise a part of their mill premises, so that to the Company commercially, with that added to it, the financial position is very different from 0.59 pence, but we thought it our duty in all cases to exclude cost of site as being a common position, otherwise it would complicate these results, so that they would contain very little information so far as you are concerned.

30082. Yes, we appreciate that. Now let me call your attention to case No. 23, where, in contrast, we have a result which appears to be very unsatisfactory ?—(*Mr. Hanson.*) It is one of the treatment disposal plants. (*Mr. Whitaker.*) It is a comparatively new plant, and although we have had an analysis taken twice, still it is not good enough, I quite admit.

30083. Now, in that case they have in the effluent 48 parts of suspended matter ?—Yes.

30084. They have quite an excessive acidity ?—Well, it is certainly acid—130 parts per 100,000, which is only .001 per cent., is it not ?

30085. The expenditure per annum is only £30 ?—Quite so. They treat their own seak, cracking it and extracting the oil from it.

30086. Now, is not that a case where it would seem to be possible for a firm to very considerably improve the results ?—Oh, yes, I quite agree.

30087. Their expenditure is only £30 for bringing it down to the point which is reached, and that is surely a case where the firm might be called upon to carry out works to very considerably improve the result ?—I think it is quite easy to do that at these works. This plant has only been in operation from four to six months, and I have no doubt at all that shortly it will be very much improved indeed. It is a case of inefficient filtration as much as possible.

30088. In that case also I may take it that the expenditure has been incurred not primarily for the purposes of purification, but primarily for the purposes of recovery of the by-products ?—No, primarily for purification ; the increase of the scouring has been rather great there, and they have had to put plant in to do it. This is only the seak plant. They have a tremendous volume of water besides which flows through the mill, and the plant has been entirely erected for purification, owing to the increase of scouring.

30089. May I ask in regard to all these samples which have been analysed, whether they are just odd samples which have been taken, or the averages of samples taken over a long period ?—(*Mr. Haigh.*) They vary. I believe they represent a fair average output from each of the premises. In some cases, where the effluent varies from hour to hour, I have had them taken every half hour during the day, and then blended. (*Mr. Hanson.*) A blend. (*Mr. Haigh.*) In some cases ; one day their dyeing predominates over their scouring, and *vice versa*. I have taken the effluent on two days and made a blend of the two, and I may say I believe each represents an average daily output from these works.

30090. But subject to that observation, most of these analyses are from single samples ?—With the exception of two cases, yes ; they are from single samples. In some cases, for instance, where the dye water and the seak effluent join, a dip sample is taken out of the sump before it is treated.

30091. On these samples as a whole I would like just to make this observation, that speaking generally, they would probably be admitted to be unsatisfactory ?—Do you mean that the average is unsatisfactory.

30092. I mean that the results cannot be considered as satisfactory results, and that the discharge of such effluents into the rivers must be considered a somewhat serious matter ?—(*Mr. Hanson.*) Well, if you deal with that by looking at the average figures at the bottom of the last page, there you get exactly what the average of these samples is, and, therefore, it looks as though that is the point to consider your question from. There the average solids in suspension over the whole of these is 11·91 as a result, and the average cost is 2·08d. That was taken exactly with a view to such a question as you have now put.

30093. But you have only given us the result in regard to suspended matter.—That is all, and solids in solution.

30094. You have not given us the result in regard to hardness, alkalinity or acidity.—That is all, because we considered, so far as acidity and alkalinity goes, that they should be dealt with—I think we made that quite clear before—and so far as hardness goes, I think you must take our answers this morning.

30095. Then in regard to the average cost that you have just referred to as 2·08d. per thousand gallons, I have this observation to make, that in a great many cases the expenditure is included which has been incurred for the purpose of recovering useful matters ?—That is so.

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otherwise the cost would be quite a different figure altogether. Wherever you find a result, at any rate in a firm of any size or with more than one branch, where you find the cost less than 2d. it is where they have only one process.

30096. Then should I be right in saying generally, that the purification of effluents, apart from the recovery of useful by-products, has not been carried very far among the members of your Association ?—(*Mr. Haigh.*) Of the eighty-seven plants mentioned in Mr. Hanson's evidence at the last hearing, twenty-eight have both seak plants and some purification for their other trade processes ; or in other words, they have what is considered a complete trade purification. Three have no other trade process but scouring, and therefore they only deal with their seak. Seventeen discharge into a sewer their untreated dye waters, and they only deal with their seak for the purpose of extracting grease. Thirty-nine have seak plants, but do not treat their other trade effluents.

30097. You do not suggest to us that the result that you have brought before us now are results in your opinion which should be considered as final ? You probably bring them before us as showing what has been done so far, but by no means as showing what can be accomplished in future ?—(*Mr. Hanson.*) The cases that are put before you this morning are cases over which we have some control, where we could first of all get the information ; and in our opinion they generally cover the woollen and worsted trade in all its branches. We think that the examples that we have given you here are typical examples: for instance, take Worsted Piece-scouring, these are fair average firms that would properly come under that head, and with all the other circumstances that might be applied generally ; but we do not consider that the information that we have been able to supply to you is anything like a sufficient basis upon which you can form an opinion as to what would be a proper standard under all these different heads, We feel very strongly that the basis wants extending and broadening before you can arrive at anything like a fair standard to apply generally to these trades.

30098. May I take it that your Association and its members admit that something more will have to be done than has already been accomplished ?—We do not think that anything more can be done than what some of these plants will produce ; certainly not. Take the case of No. 16, we think that so far as their case goes, that is a result that cannot be obtained by all other firms ; some have not the capital to begin with, and that is a part of this question, otherwise the trade will be affected.

30099. I can quite understand your not desiring to admit that everyone should be made to obtain the best result which has been obtained —Certainly not.

30100. At the same time this Commission, enquiring into these matters, is anxious to see what has been possible of attainment in certain cases, and how far the cost of attaining it has been a practicable one.—It is with that object that we prepared this information.

30101. I am not struck in looking through these papers that you have brought before us with any excessive cost to which manufacturers have gone in endeavouring to solve their difficulties. Considerable sums have in certain cases been spent, but they have been spent largely for the purpose of recovery.—That is where the great capital cost arises, both so far as labour and material are concerned.

30102. We are not asking you to admit on behalf of your Association that a good deal more ought to be done. You would admit, would you not, that these effluents in many cases are unsatisfactory effluents ?—Certainly I do. There are some of these cases which are capable of a great deal of improvement, and I admit ought to be improved, but there are others which have attained a standard which certainly the average trader cannot reach. That is my short point.

30103. I should like to call your attention to evidence which we had yesterday from Mr. Roberts, a woollen manufacturer in Selkirk, and he told us that without any pressure from any authority he had considered it his duty to carry out works for improving his effluent. He did not give us any particulars of the cost of the seak plant which he had had in operation for a great many years, because apparently he considered he had spent that for general business purposes, for purposes of the recovery of grease, but he gave us the cost that he had incurred in trying to purify the acid effluent from the seak tanks, mixed with his dye and other waters ; and he told us that he had expended altogether a sum of £2,000 in a plant which I believe was designed by Messrs. Mather & Platt, and the annual expenditure upon which was, including interest on outlay and sinking fund, some £280. His total flow was 170,000 gallons, and I think if you reckon that out you will find that the cost comes to about 1·2d, or 1¼d. per thousand gallons. That case seemed to us to be reasonable, and this manufacturer expressed to us his conviction that the result would be found by us to be satisfactory. We have not yet examined it, but we shall examine into it ; I call your attention to it because it is in a branch of the same trade in which your Association is interested, and it might possibly be worth while for Mr. Hanson or Mr. Haigh to see Mr. Roberts upon it, and see whether the results attained fulfil the expectations which have been laid before us.—I quite think that if 1·2d. would represent as a cost a standard which could be a standard for a particular trade produced by a particular plant and satisfactory to you, from a purely commercial standpoint 1·2d. is not excessive, and I think it is a fair sum that they should be asked to expend ; or, if 1·2d. on any plant that can be devised will produce a result satisfactory to this Commission, I think at any rate I may speak for the Association with which I am connected, that that outlay would not be considered an excessive outlay.

30104. (*Mr. Tatton.*) Mr. Hanson, you mentioned thirty-nine works where they have seak tanks only, and the rest of the trade waste is discharged into the river with it ?—(*Mr. Haigh.*) Yes, that is so. I have the figures before me. Thirty-nine have seak tanks only, and the rest of the trade effluents are untreated.

30105. Nothing further is done at all. Now, in most of these cases could not a large proportion of these works put down plant for treating their waste ?—Yes.

30106. All of them ?—For all I know, nearly all of them. There may be some who may have difficulties as to site, no land available, and so on, but the majority of them certainly could do something.

30107. They have taken no steps about it ?—Well, I do not know that.

30108. Still, they have not put down works ?—They have not put down works.

30109. With regard to the question of waste products, has anything been done for the recovery of these in any works in Yorkshire that you know of ?—Other than the grease recovery ?

30110. Yes, other than the grease recovery ?—Well, I do not know of any ; I have heard that they have tried to recover indigo, but I do not think they have been very successful.

30111. Well, that is what I was coming to, because I see in your notes under Works, No. 8, you say the solids in suspension are largely fine particles of indigo. Well, surely that should be recovered ?—Well, it is fine indigo that comes from the washing of the indigo-dyed pieces. I do not know that it is recoverable, except to a slight extent. (*Mr. Whitaker.*) It is done in Lancashire. (*Mr. Haigh.*) There is no waste from the indigo vats themselves ; they do not waste any there, it is only what comes from the washing They dye largely in these works blue navy cloth and that sort of thing.

30112. In many places they do recover the indigo ?—(*Mr. Whitaker.*) Yes, in Lancashire. (*Mr. Haigh.*) Is its recovery a profitable process ?

30113. Certainly ; oh, yes

30114. (*Sir William Ramsay.*) Another substance which might be recovered, and which I fancy is not recovered, is potash for wool washing.—(*Mr. Whitaker.*) This effluent does not contain any potash. The wool has been previously washed.

30115. (*Mr. Tatton.*) With regard to works No. 23, was I right in understanding that that refers to the seak plant only ?—To the seak plant only.

30116. But that there are other waste products from the works ?—Dye water.

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30117. Is there a large volume of dye water ?—A large volume of dye water.

30118. I see ; then that does not represent the effluent ?—Not at all ; that is only from the seak plant. That is only quite a new one as I have said ; I do not know the volume exactly.

30119. What is the difficulty about treating the dye water there ?—Well, they do treat it to a certain extent there.

30120. But you do not give it here ?—I do not give it here, no. This is a question of plant that has been put in for scouring effluent only.

30121. Yes, but I mean to say, you have got 48 solids in suspension in the treated effluent ; that could not be taken as an average from these works ?—Oh, no ; not at all. You might take the next one as an average ; practically similar works those two. But one has been working for some time, and the other is only comparatively new, and I think the filtering plant there is wrong, besides which I think they get more hard water with the soapy water than they ought to have.

30122. Then that 48 ought to be eliminated ; therefore that 11 average is wrong ?—Well, it would bring it down.

30123. It would if you eliminate these obviously bad ones.—Then you would have to eliminate the obviously good ones with Waite's plant, because the purification with Waite's plant is excessive.

30124. No. 1 ?—Not No. 1. (*Mr. Hanson.*) No. 4. 1·6 of solids in suspension.

30125. 1·6 of solids in suspension ; of course, this is very good, 1·6.—(*Mr. Whitaker.*) Yes, it is very good, but it is obtained at the cost of the hardness of the water to a great extent there, if colour is not to be taken into account.

30126. That is one good one, but you would have to eliminate a great many bad ones ; therefore that eleven would be very much reduced ?—Oh, yes. (*Mr. Hanson.*) At any rate, I would draw your attention to the cost ; 3·64d. is the cost of producing that good result.

30127. Which one ? I did not quite catch it ?—No. 4. You have been referring to the 1·6 of solids in suspension as being excellent, but I call your attention to the cost of attaining it—3·64 pence per thousand gallons.

30128. Quite so, that is a high price, I know.

30129. (*Sir William Ramsay.*) Reverting to the point which I raised before, as regards the hardness of the water and the necessity for purifying it, if it is required for boiler purposes, might I ask first if there are many of these works on the same stream ? Do many of them take waters ?—(*Mr. Haigh.*) No. 15 is at the top of a stream, and No. 16 is only a little lower down, the second mill down on the same stream.

30130. Are there many cases of this sort ?—(*Mr. Hanson.*) Oh, yes, there are many works on that stream, thirty over a distance of 12 miles.

30131. I understand it is theoretical in law that if the water is taken from the stream, it must be returned to the stream in similar volume ?—That is so.

30132. Would it not be a great extension of the same principle if it were also enforced, if the water were returned to the stream in the same or a better state as regards suspended solids and hardness ? Then each man would return the water, so far as these points are concerned, in the same state as he got it, and his neighbour down the stream would have no cause of complaint ?—But as you go down the stream it would cost the trader so much more to do it.

30133. Would it, because it is turned in in each case ?—You mean an equal per cent. of pollution ?

30134. Suppose, for example, there were 10 degrees of hardness when it entered the first works ; that was the natural state of the water. It was used and made harder by the proprietors of that works on the stream ; the proprietors would have an obligation to return it to the stream with 10 degrees of hardness, so that the people below them would have a water equal to the original water of the stream ?—(*Mr. Hanson.*) Should not that be after dilution with the stream ?

30135. Perfectly right, but do you not think it would be a reasonable standard ?—(*Mr. Whitaker.*) I think you ought to consider the question of colour. The bulk of the lime used here is for neutralising the acid or decolourising the effluent. If the colour is no objection, you would be able to reduce the lime considerably, and so reduce the hardness.

30136. I suppose the colour is of no importance. There is very little of it there, because a little colour goes a long way ?—Yes.

30137. These are not streams for drinking or fishing purposes ?—Not at all.

30138. (*Mr. Tatton.*) Are you not protected in regard to colour ?—We think so ; the Rivers Board think not.

30139. (*Sir William Ramsay.*) It would make no difference in a boiler whether the water were coloured or not ?—It is better coloured than discolorized and rendered excessively hard.

30140. Previous contamination of water with colour would spoil it for dyeing purposes, would it not ?—(*Mr. Hanson.*) You may take it that the twenty-fifth or twenty-sixth mill down the stream to-day use it for dyeing the brightest colours you can imagine. That statement of mine I made before the Local Government Board Inquiry that was held, in the first case, under the 1894 Act of the Yorkshire Rivers Board, that the trader would prefer to have the water foul as it is to-day for his dyeing, than to have the chemical character of it changed in other respects. These dyers are bred in the West Riding, as Colonel Harding knows ; there have been dyers in the families for generation after generation, and they dye very largely by rule of thumb. It is not a scientific process with them, but they are very, very exact in their results, very successful.

30141. Then may I take it that you would agree to this proposition of mine, that the river should be passed from works to works with a stipulation that its suspended solids and its hardness should not be increased ?—Well, I should prefer personally, for the moment, not to give an answer to that.

30142. Would you rather allow yourself to say that it appears fair ?—(*Mr. Whitaker.*) I do not think so. (*Mr. Hanson.*) You see, at present we are touching riparian positions. Now there is not a riparian right on the River Colne but what is infringed by every trader on the Colne, and has been from time immemorial, but there is no litigation, no trouble.

30143. But there must be some grumbling ?—Well, I have had the privilege of practically managing all these firms on this question for the last thirty years, and you may take it from me there is no grumbling, because they know it has got to exist at presént.

30144. (*Mr. Tatton.*) Have they given up all hope ?—They make the best of their difficulties ; there is nothing but absolute diverting of water that we have had difficulty on, and that is very slight.

30145. (*Sir William Ramsay.*) I notice there is difficulty with the boilers ?—With boilers there is a little, but there is far more since traders begun to treat, which is your point. More difficulties have arisen ; in fact, I called the attention of the Commission to that fact last time I was here.

30146. It does not appear material who purifies the water ; that is a matter of arrangement ; it may be the receiving mill or the mill which sends off the water, but it appears to me a very simple arrangement which could be made by the proprietors of the works on any particular stream, that the water should be received by the man below in the state in which the man above had got it from the stream, so far as its important characteristics were concerned ?—As a principle it does seem fair, but when one comes to look at the sort of machinery which would have to be provided to carry out a proposition of that sort, I am afraid we will be getting into very great

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difficulties. It is not as if you could say at the moment, this stream is of a certain character, and it has got to remain so for all time. It would be a matter of fact, to enquire into the case.

30147. It would require to be a matter of arrangement at first ?—(*Mr. Whitaker.*) It would vary a great deal.

30148. It would vary from stream to stream ?—(*Mr. Hanson.*) The conditions of the river. (*Mr. Whitaker.*) It is no unusual thing for the water to rise very much within an hour's time in some of these streams with the result that the stream is very much softer in character.

30149. Quite so ! Is it a matter which you think might be left to either the Rivers Board or a Central Authority, to make such an arrangement, and to make a provisional standard ?—Standard as to what ?

30150. As to important matters in regard to your streams, suspended matters and hardness.—Suspended matters, yes ; hardness I do not think they ought to consider at all. Neither ought they to consider colouring matter.

30151. Well, we agree rather about that ?—If you get rid of the colour bogey, you could reduce your quantity of lime and hardness proportionately.

30152. (*Mr. Tatton.*) What is the colour you use all this lime to get rid of ?—Generally, if it is a coloured effluent, you use lime.

30153. (*Sir William Ramsay.*) Would not alumina ferric give you better results ?—In some cases, yes.

30154. Is the lime not to reduce the sulphuric acid ?—In the bulk of the cases here where you find there is a seak plant, yes, that is so ; but apart from that coloured water, I believe Mackey's plant is practically nothing but lime. (*Mr. Haigh.*) In Mackey's plant the precipitant is nothing but lime practically ; it deals with dyewater only, there is no soap there.

30155. It would be a very good precipitant. Anyhow, you would get sulphate of lime thrown down to some extent, which would be quite a good precipitant for colouring matter.—No. 15 uses lime and copperas.

30156. Yes, a mixture of the two would do very well.

30157. (*Mr. Tatton.*) Are the filter beds all streaming filters ?—No, in one case it is a sprinkling filter ; you call that a streaming filter, do you ?

30158. Yes. It is not held up ; it is not a contact bed ?—No, it is not a contact bed. There are none of them contact beds.

30159. (*Chairman.*) Well, thank you, gentlemen, very much for all the trouble you have taken.

Mr. John H. Hanson, Mr. John Haigh and Mr. Thorp Whitaker.

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TABLES OF ANALYSES HANDED IN BY MR. JOHN H. HANSON, MR. JOHN HAIGH, AND MR. THORP WHITAKER.

ANALYSIS OF TRADE EFFLUENTS.

Expressed in Parts of 100,000.

BLANKET DYEING AND SCOURING.

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Discharge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation.	Including interest and depreciation, less value of by-products.		
1	Mixed Liquors -	1752·0	1196·0	556·0	318·0	220·0	98·0	96·5	—	10·8	85·0	Yellow. Black Sediment.	Settling Tanks. Filter Beds. Sludge Lagoon.	Pence.	Pence.		
	Effluent after Treatment - -	9·6	4·0	5·6	159·4	140·0	19·4	12·25	—	None	30·0	Straw.		1·60	1·25	Sewer.	Large quantity of Fuller's Earth. No Precipitant used.
2	Crude Scouring Liquor - - -	1874·0	1224·0	650·0	64·8	43·2	21·6	8·82	—	8·5	35·0	Dark Grey.	Settling Tanks. Filter Beds.				Dye Waters into Sewer untreated. Large quantities of Fuller's Earth renders Seak valueless. Cost of Treatment will increase with difficulty of disposing of Solids. Gravitation Scheme.
	Effluent after Treatment -	8·6	4·66	3·94	73·2	56·0	17·2	14·7	—	1·75	19·6	Nearly Colourless.		5·45	—	Sewer.	

FLANNEL DYEING AND SCOURING.

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Discharge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation.	Including interest and depreciation, less value of by-products.		
3	Crude Seak before Treatment - -	143·6	15·6	128·0	1239·4	380·4	859·0	313·6	—	146·0	14·3	Dense Opaque Grey.	Seak Tanks. Magma Filter.				
	Mixed Acid Seak Effluent, untreated Scour and Dye Waters	9·6	1·6	8·0	153·2	119·6	33·6	—	23·52	0·75	33·71	Colourless, Slightly Turbid.		—	—	Sewer.	

LOW CLASS WOOLLEN DYEING AND FINISHING.

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Discharge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation.	Including interest and depreciation, less value of by-products.		
4	Mixed Liquors -	14·4	4·4	10·0	227·6	198·6	29·0	—	2·50	0·7	74·0	Greenish.	Thomas Waite & Co.'s Plant.				
	Effluent after Treatment - -	1·6	1·2	0·4	198·4	178·8	19·6	7·3	—	4·0	80.0	Straw.		3·64	—	Stream.	Aniline Dye and Myrabolum Extracts. Effluent re-used for Boilers.
5	Mixed Liquors -	86·0	12·0	74·0	406·0	363·0	43·0	100·5	—	10·8	43·0	Black.	Seak Tanks. Settling Tanks. Magma and Water Filters.				The Seak is taken and treated by an outside firm, they paying a rent for which credit is given. Crude Seak not in samples analysed. Precipitant, Lime.
	Effluent after Treatment - -	18·4	10·0	8·4	193·6	181·0	12·6	24·5	—	1·3	70·0	Pale Straw.		2·49	1·84	Stream.	

LOW CLASS WOOLLEN DYEING AND FINISHING—*continued.*

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Discharge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation	Including interest and depreciation, less value of by-products.		
														Pence.	Pence.		
6	Mixed Liquors -	15·6	1·2	14·4	145·4	73·0	72·4	31·9	—	1·6	49·0	Bluish.	Mackey's Plant.				
	Effluent after Treatment - -	1·2	0·8	0·4	155·0	133·0	22·0	10·3	—	None	90·0	Pale Green.		No information.		Stream.	
7	Mixed Liquors -	32·7	4·6	28·1	425·3	353·4	71·9	71	—	10·7	120·0	Bluish.	H. P. Watson, Ltd., Plant.				Crude Seak dealt with by an outside firm, and credit given for rent. Sample analysed includes Seak Effluent.
	Effluent after Treatment - -	6·0	2·4	3·6	461·0	437·6	23·4	—	Slightly Acid.	Trace	105·0	Pale Blue.		15·99	1·12	Stream.	

FINE WOOLLEN AND WORSTED DYEING AND FINISHING.

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Discharge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation	Including interest and depreciation, less value of by-products.		
8	Mixed Liquors -	40·8	11·2	29·6	226·0	197·0	29·0	38·6	—	1·8	55·0	Violet. Black Sediment.	Settling Tanks. Filter Beds. Sludge Lagoons.				Sample taken every half-hour, one day's flow. Settling Tanks only. Filters not used. Precipitant, Alumino ferric Plant worked by Sub-Contractor at a cost to the firm of £180 per annum. Gravitation Scheme.
	Effluent after Treatment - -	11·2	5·2	6·0	128·0	113·0	15·0	27·2	—	None	41·0	Straw.		2·95	—	Stream.	
9	Mixed Liquors -	12·0	4·0	8·0	155·0	134·0	21·0	—	—	—	28·0		Sand Filters and Settling Reservoirs				
	Effluent after Treatment - -	5·0	2·0	3·0	143·0	122·0	21·0	—	—	None	28·0	Pale Blue.		2·76	—	Stream.	
10	Mixed Liquors -	13·0	6·0	7·0	71·0	46·0	25·0	10·2	—	1·4	7·0	Bluish.	Archbutt Deely Plant modified.				Crude Seak not in Samples analysed.
	Effluent after Treatment - -	3·6	2·0	1·6	61·4	53·0	8·4	13·2	—	None	30·0	Pale Straw.		7·77*		Stream.	
11	Mixed Liquors -	6·8	3·2	3·6	34·4	24·4	10·0	10·04	—	1·75	8·0	Opaque but thin.	Settling Tanks. Neutralising Tanks. Sprinkler Filter. Magma Filters.				
	Effluent after Treatment - -	4·0	0·8	3·2	37·6	31·2	6·4	10·78	—	0·12	7·4	Colourless.		1·52	—	Stream.	
12	Mixed Liquors Untreated - -	20·4	9·6	10·8	23·3	20·3	3·0	5·4	—	4·7	42·0	Black.				Stream.	No Treatment.

"This cost includes the extraction of the residuals, but we have no information as to their value."

HEAVY FINE WOOLLEN DYEING AND FINISHING.

														Pence.	Pence.		
13	Mixed Crude Seak from Wool and Pieces and Dye Waters before Treatment - -	340·6	21·33	319·27	170·7	69·3	101·4	7·84	—	143·5	9·3	Brownish Opaque.	Seak Tanks. Settling Tank. Magma Filters. Water Filters.				
	Effluent after Treatment - -	11·6	4·0	7·6	228·8	174·8	54·0	1·96	—	0·75	20·0	Darkish Green Transparent.		5·87	0·65	Stream.	
14	Mixed Liquors -	294·0	46·0	248·0	632·0	335·0	297·0	260·0	—	475·0	8·6	Bluish.	Seak Tanks. Magma Filters.				Seak Plant in operation only for Piece Scouring and Wool Washing. Dye Waters not treated.
	Effluent from Wool and Piece Scouring after Treatment - -	34·0	7·5	26·5	573·0	329·5	243·5	—	3·9	32·0	190·0	Pale. Turbid.		—	—	Stream.	

MEDIUM CLASS WOOLLEN DYEING AND FINISHING.

15	Blend of Crude Seak and Dye Liquor - - -	1562·94	234·51	1328·43	626·51	427·39	199·12	314·95	—	110·4	5·68	Dark Green Opaque.	Seak Tanks. Settling Tanks. Magma, Sludge, and Water Filters.	—	—		Treated Effluent average of Samples taken on two days.
	Effluent after Treatment -	14·8	3·1	11·7	142·6	99·2	43·4	4·9	—	3·5	23·82	Light Green.		2·82	2·53	Stream.	
16	Crude Seak before Treatment	360·0	55·0	305·0	479·0	239·0	240·0	156·31	—	44·5	—	Deep Black.	Seak Tanks. Settling Tanks. Magma Filters. Sludge and Water Filters.	—	—		Treated Effluent average of Samples taken on two days.
	Mixed Acid Seak Effluent and Dye Water before Treatment	50·8	7·4	43·4	270·4	227·2	43·2	2·94	—	1·85	11·7	Deep Green.		—	—		
	Effluent after Treatment - -	7·2	2·8	4·4	160·6	138·6	22·0	5·14	—	0·25	28·57	Brownish Green.		6·65	0·59	Stream.	
17	Mixed Crude Seak and Dye Water	208·0	24·8	183·2	469·2	240·2	229·0	110·74	—	78·0	9·57	Black.	Seak Tanks. Settling Tanks. Magma Filters. Sludge Filters. Water Filters.	—	—	—	—
	Effluent after Treatment - -	6·6	0·8	5·8	301·4	263·2	38·2	—	34·3	2·25	46·3	Greenish Yellow.		4·81	2·63	Stream.	

ALPACA AND MOHAIR DYEING AND FINISHING.

18	Crude Seak before Treatment - -	303·0	89·0	214·0	432·0	159·0	273·0	106·8	—	184·2	None	Pale Fawn.	Seak Tanks. Magma Filters. Continuous flow Precipitation Tanks.				
	Dye Water before Treatment - -	23·2	7·6	15·6	187·8	176·4	11·4	26·6	—	Trace	1·4	Black.					
	Effluent after Treatment - -	8·8	4·0	4·8	196·2	168·0	28·2	11·2	—	1·2	65·0	Pale.		3·79	—	Sewer.	Seak cracked with Vitriol. Precipitants, Lime Solution and Alumino-ferric. Sludge pressed.

Mr. John H. Hanson, Mr. John Haigh, and Mr. Thorp Whitaker.

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COTTON DYEING AND PRINTING

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Dis-charge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation.	Including interest and depreciation, less value of by-products.		
														Pence.	Pence.		
19	Mixed Liquors -	47·2	20·8	26·4	144·0	66·0	78·0	—	—	—	34·0		Settling Tanks.				
	Effluent after Treatment - -	26·8	5·6	21·2	140·0	50·0	90·0	—	—	None	31·0	Blue.	—	0·31	—	Stream.	—
20	Mixed Liquors -	30.6	16·0	14·6	200·0	113·0	87·0	—	—	—	24·0		Settling Tanks and Filter Beds.				
	Effluent after Treatment - -	15·4	6·9	8·5	136·0	90·0	46·0	—	—	None	21·0	Yellow.	—	0·23	—	Stream.	—

COTTON DYEING AND BLEACHING.

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Dis-charge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation.	Including interest and depreciation, less value of by-products.		
21	Mixed Liquors -	11·0	3·3	7·7	271·0	153·0	118·0	—	—	—	26·0		Settling Tanks and Filter Beds.				
	Effluent after Treatment - -	7·7	2·1	5·6	172·0	95·0	77·0	—	—	None	20·0	Straw.	—	4·9	—	Stream.	Plant too large for out-put (20,000 gallons per day).
22	Mixed Liquors -	76·0	—	—	197·0	—	—	—	—	—	20·0		Archbutt Deely Plant.				
	Effluent after Treatment - -	8·1	3·1	5·0	221·0	120·0	101·0	—	—	None	40·0	Pink.	—	2·16	—	Stream.	—

WORSTED PIECE SCOURING.

No. of Sample.	Description of Sample.	Solids in Suspension.			Solids in Solution.			Alkalinity in terms of H_2SO_4.	Acidity in terms of H_2SO_4.	Fatty Matter (extracted by Ether).	Total Hardness in terms of $CACO_3$.	Colour of Sample.	Description of Plant.	Cost of Treatment per 1,000 gals., exclusive of cost of Land.		Dis-charge into.	Notes.
		Dried at 100°C.	After Ignition.	Loss on Ignition.	Dried at 100°C.	After Ignition.	Loss on Ignition.							Including interest and depreciation.	Including interest and depreciation, less value of by-products.		
23	Crude Seak before Treatment - -	135·0	60·0	75·0	312·0	176·0	136·0	29·0	—	179·0	—		Seak Tanks. Magma Filters.				—
	Effluent after Treatment - -	48·0	22·0	26·0	310·0	258·0	52·0	—	130·0	None	21·0	Milky.		10·17	1·04	Stream.	
24	Crude Seak before Treatment - -	207·0	40·0	167·0	137·0	67·0	70·0	41·0	—	—	Nil		Seak Tanks. Magma Filters.				—
	Effluent after Treatment - -	4·0	1·2	2·8	220·0	93·0	127·0	—	100·0	Trace	21·0	Milky.		4·8	1·92	Stream.	
	Average of Effluents after Treatment - -	11·91	—	—	200·5	—	—	—	—	—	—	—	—	—	Net Cost 2·08	—	—

Mr. H. W. Hart, F.C.S., and Mr. Potter, representing the Wall Paper Manufacturers, Ltd., called in; and Examined.

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30160. (*Chairman.*) You have been good enough to prepare this statement for us. May we take this as it is, and put it into our evidence ?—(*Mr. Potter.*) We have no objection.

30161. Thank you, that gives your views altogether ?—Generally speaking, yes.

(1) Upon what principles should the Commission proceed in framing recommendations as to the extent to which a manufacturer should be required to purify his trade effluents before discharging them into a river or stream ?

In answer to this Question we beg respectfully to submit that due consideration should be paid to what is practicably and reasonably available, following the words of Clause 6 in the River Pollution Act of 1876, and the interpretation put upon these words by Mr. Justice Bruce, in the Ribble Joint-Committee *v.* Almond & Co., in the High Court of Justice, Queen's Bench Division, Manchester Assizes, July, 1898, where his lordship held that "reasonably available" means reasonably available from a business point of view.

Observations.

As determining what is reasonably and practicably available, regard should be paid :—

(*a*) To the nature of the goods manufactured at the particular mill under consideration and the consequent nature of the raw materials employed.

(*b*) To the position and surroundings of the mill, available land, position on stream, volume of the stream and the locality, and also to the industrial interests involved.

(2) Should there be fixed standards for various trades, and, if so, should the law provide means by which the standard could be raised or lowered according to the character of the stream ?

In reply to Question (2) we submit that no general standard can be set up for a particular trade for the reasons already stated in paragraph (*b*) in answer to Question (1).

Observations.

As to the question of standards, it is our opinion that a special standard should be settled with each mill by taking cognizance of the business carried on at each mill, and the subjects mentioned in paragraph (*b*), Question (1). This, in effect, is what is actually done now in Lancashire, but the policy of the Pollution Authorities is non-committal, and is always uncertain, the manufacturer, even if willing to do what is reasonably possible, is harassed and rendered hostile, the maximum expense is thrust on him, and there is no guarantee that such expense will render him immune from legal proceedings.

(3) What methods are available for purifying trade effluents of various sorts within reasonable limits of cost, and what is the character or quality of the purified effluents produced by such methods ?

In answer to Question (3), the methods available for purifying the crude effluent from paper mills are sedimentation, filtration, or a combination of both, assuming land to be available for this purpose. Owing to the large volume of water employed in manufacturing paper, the use of precipitants soon runs into prohibitive costs. By means of sedimentation and filtration, an effluent containing a small quantity of matters in suspension and a large proportion of matter in solution is attainable in most cases at a reasonable cost and these are not of a particularly noxious or putrescible character.

Observations.

We should like to give our experience of two typical paper mills in Darwen; one, the Almond & Co. Mill, referred to above, making a very common class of paper and situated in a thickly populated district, being in the centre of the borough, with little or no land available as a site for purification works; the other, Hollins Paper Mill, making a better class paper for printing and wall papers with land available for purification works.

In the case of the Almond Mill, we had an average effluent of 175,000 to 200,000 gallons for twenty-four hours, charged with over 300 parts of suspended matters per 100,000 parts of water and about 250 parts of dissolved matters per 100,000 parts of water. We installed a settling tank with a capacity of about 14,000 gallons, which was as large as our land would admit, and a filter press with pumps, etc.

We expended at the time of the trial a capital sum in purification plant of £1,300 and involving an annual working expenditure of £680.

The Local Government Board gave leave to prosecute, and the case went for trial before Mr. Justice Bruce, in the Manchester Assizes, 1898.

We admitted pollution: the effluent discharged into the river contained on the average about 20 parts of totally suspended matters, and a little over 250 of total dissolved matters.

The case was decided in our favour on the ground that we had done all that was reasonably and practicably available under Clause 6 of the Pollution Act of 1876, and it was shown in evidence that in a mill of this class, producing a little over 3,000 tons of paper per annum, at an average value of £8 1s. 4d. per ton, had we adopted the scheme suggested by the Ribble Joint Committee's inspector, Mr. Naylor, we should have been involved in an annual expenditure of £1,320 per annum or a charge of 8s. 4d. per ton of paper, amounting to over 5 per cent. on the turn-over.

Evidence by two paper experts on this class of trade showed that a sixteenth of a penny per lb. on the paper produced (11s. 8d. per ton) by any manufacturer, constituted the difference between working to a profit and working to a loss.

We may state that since this time we have shown our good faith and desire to meet as far as possible the wishes of the Pollution Authority by spending more money in raising the height of the tank and thereby increasing its settling capacity.

With regard to our Hollins Mill, we have spent a large amount of money in works to prevent pollution both inside the mill and outside. The precipitation tanks, pumps, piping, presses, namely, the purification works external to the mill, involved alone an outlay of £5,700 with an annual working cost of £1,500. This is up to the year 1898. Besides this the cost of the internal arrangements for preventing pollution has been considerable.

This mill has an average effluent of 800,000 gallons of water per twenty-four hours, which will average about 10 to 12 parts of total suspended matters per 100,000 of water, and about 150 of total dissolved matters per 100,000 of water at the point of discharge into the river.

Owing to the use of esparto grass and materials requiring the use of bleaching powder, the effluent discharged from our purification plant to the River Darwen was alkaline, for which no reasonable cure can be suggested.

We have calculated out that to neutralise this alkaline effluent would require per twenty-four hours 7,680 lbs. of commercial hydrochloric acid, which, at 2s. per carboy (about 1 cwt.), would cost us £30 a week; or, if commercial sulphuric acid of 80 per cent. strength were employed, 3,900 lbs. per twenty-four hours would be necessary at 45s. per ton, £19 10s. per week.

The effect of alkalinity in our effluent, even when it is clear, frequently produces precipitation and turbidity at the point of confluence with the river.

It should be noted on the other hand, that mills dealing with comparatively large quantities of lime residues find their crude water settles fairly quickly in the sedimentation tanks, and further that the sludge so settled out, is comparatively easy to deal with in filter presses; it is not so slimy and difficult to press as it otherwise would be, but the sludge so obtained rapidly accumulates and is difficult to dispose of and very heavy expenses are entailed in dealing with it, even if ground be available close to the mill site.

We regret that the Commission did not see their way to visit this (Hollins) mill during their visit to Darwen last May.

(4) Whether there are any cases in which manufacturers experience difficulty in satisfactorily purifying or disposing of trade effluent ?

In reply to Question (4), we beg to state that this question is answered in the affirmative in our observations

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under Question (3), but we would further add that the owner of a mill has no compulsory power of acquiring land or easements over land, but is at the mercy of the neighbouring landowner, if he must acquire land to meet the requirements of the Local Authority; the price is therefore, always raised against him. Moreover, the difficulties referred to in the question would vary according to the nature and characteristics of the paper made at mills of different classes. For instance, a paper mill making news from chemical and mechanical pulp with the ordinary sizing and loading additions, and where the use of bleaching materials is not entailed, does not produce the dirty effluent which would come away from another mill in the same stream using, say, dirty rags, esparto and material requiring bleaching, involving the installation within the mill of elaborate and costly plant to deal with the dirt and non-paper-making material separated from the raw material in the preparing processes, and it is possible for the news manufacturer to effect the purification of his crude water to a very large extent within his mill by the use of the continuous filters which have been largely adopted for the last few years, whereby the suspended materials (fibre, loading material in a comparatively clean condition) is reclaimed, and in many cases, is in a fit condition to be returned to the manufacture.

We contend, therefore, that what is comparatively easy to accomplish in a news mill becomes practically impossible in another, and that great discrimination and practical knowledge must be brought to bear in forming a judgment on the effluents of various classes of paper mills.

(5) Whether any alterations of the law are desirable in regard to trade effluents and manufacturing pollutions generally ?

In reply to Question (5), we deprecate any serious change in the law as it stands, especially with regard to the protection afforded to manufacturers under Clauses 4 and 6 in the Act of 1876.

Observations.

The authorities and manufacturers in Lancashire have arrived, after long years of negotiation and litigation, at a working basis which is, in practice, about all that trade competition permits manufacturers to do. Great expense and waste may be caused by change of the law, but the final result cannot differ materially from the present achievement without seriously jeopardising the existence of the industry. Whatever alterations in the law may be recommended, we hope the safeguards to manufacturers given by the Act of 1876 will be retained.

We suggest that the law might be altered so as to provide that the manufacturer should be furnished as of right, with a copy of the Local Government Board's Inspector's Report when the Board give liberty to prosecute. In Almond's case we were denied a copy of such Report, which placed us at a great disadvantage in making our position good before Mr. Justice Bruce.

30162. And then of course any members of the Commission may put any questions they like ?—(*Mr. Potter.*) Certainly. May I explain, I used to be in charge of these works, but it is some ten years since I have been living there, Mr. Hart was our chemist at the time when these proceedings took place, and is now resident there, and is much more conversant with the question. I therefore thought it better for Mr. Hart, the chemist, to prepare the evidence, and to answer any questions. I shall be glad to supplement anything if you require it from me.

30163. Quite so. Then so far as I am concerned, I have very few questions to ask. What is the state of the river Darwen when it gets to your works ?—(*Mr. Hart.*) It is already polluted.

30164. Largely polluted ?—Well, we have twenty-one manufacturers—twenty now, I think—above us, within the radius of the township of Darwen.

30165. (*Sir William Power.*) Do you have to purify the water before you begin to use it for your purposes ?—Yes, we have to purify it by impounding. We take the river in and pass it through settling tanks on its way to the works. The settling tanks are in the works buildings just below the floors. I am speaking now of our Almond Mill, which was the case we had some litigation about with the Ribble Joint Committee.

30166. What is your objection to the raw water; is it to the colour, or is it organic pollution, or what ? Is it too much coloured for your processes ?—It is too dirty, too foul; it contains considerable quantities of matter in suspension, which would make our paper dirty.

30167. And the process you adopt takes out the suspended matter ?—Yes, it is a matter of sedimentation purely and simply. I refer now to our Almond Mill, where in fact our main supply is the River Darwen itself.

30168. (*Chairman.*) Then at your other mill, is it also the Darwen that supplies it with water ?—No, we have a prescriptive right. (*Mr. Potter.*) We have a prescriptive right to the extent of about 1,000,000 gallons a day there, which come in from the hills on either side, and some we pump from the old coal workings underneath the neighbouring land, and there we make a better class of paper. The Hollins Mill is about a mile and a half below Almond Mill on the same stream, and we make papers there up to the quality of cheap writings, but we can no longer make them now up to that quality, because of the dirt in the district.

30169. The water you use for your Hollins Mill is pure water ?—Pure water from the hills, or from underground

30170. And where does that water go after you have used it ?—Into the river.

30171. Into the Darwen ?—Yes.

30172. And in fact that water from the hills is your own water, so to speak; it is used for nothing else but your mill ?—There is one user who has a right to a sufficient supply for his boilers.

30173. (*Sir William Ramsay.*) May I take your paper in the order in which you mention the points ?—Yes.

30174. As regards your observations on question (1), would it not be very difficult to determine any standard, paying consideration to the nature of the goods manufactured ? It appears to me a most indefinite thing to base a standard upon. I imagine the idea would be that you were to return to the river a satisfactory effluent. Could the satisfactoriness of that effluent be possibly based upon the nature of the goods manufactured in the mill ?—Looking at it from a rather different standpoint, we maintain as to what is reasonable and practicably available, that in order to determine that, you must have regard to the nature of the raw materials which are employed in the manufacture of the paper, the class of paper being made as well as other local conditions, as put down here.

30175. It appears to me hardly fair. Supposing a man makes wood pulp paper—I put an extreme case, I believe it does not come forward in this country at all practically, that is, that he purifies his own wood pulp and produces sulphite liquors—he does that, of course, at his own risk, he produces a very noxious effluent, he ought to be treated differently from a person who employs, say, rags, and who has very little noxious effluent of any kind at his disposal. I am stating a very extreme case. That sulphite effluent is an extremely difficult substance to get rid of ?—It is extremely difficult to deal with.

30176. Yes ?—If that manufacturer were situated where he had a mill running, it would be very hard on him to say: "Well, you must turn out as pure an effluent now under these new regulations as a man making newspapers, and not making wood-pulp papers at all." It would be a handicap probably that would prohibit his industry altogether.

30177. It probably would ?—Yes.

30178. Then do you think it is possible to make a general standard for the trade ?—No, I think not.

30179. Would it not necessitate an enormous amount of inspection, supposing you were to standardize each separate works ?—No, not more than at present as regards inspection. It would involve work, in the first instance, to determine what was a satisfactory standard from all points of view for that particular mill. It would require expert and technical knowledge to decide what was a satisfactory standard, but having decided that, I do not see that it is going to involve any more labour than the present system, where, in the Ribble Watershed, you have the Inspector and sub-Inspectors making frequent visits to each of the mills. They come round to us very frequently indeed. That all entails supervision, of course.

30180. Yes, I see ?—The difficulty would be in initially deciding what was a legitimate standard for that particular mill.

30181. Quite, but that might be done. Do you not think it would require the assent of other owners of mills on the stream or could it be done without their assent? I am thinking of a work of that kind pretty far up a stream, which is producing a very polluting effluent. Would not the mill-owners on the same stream below not object to the stream being made polluted by such a thing ?—Well, presumably any legislation, any laws passed would not allow a stream to be made any fouler to-morrow than it is to-day.

30182. They would just take the present state of affairs ?—We are working at Almonds, as you will observe from this evidence, under disadvantageous conditions, inasmuch as we do not take clean water into our mill in the first instance, but I cannot imagine that anything you gentlemen propose to do would make the state of the river worse in the future than it is to-day, so if you did anything at all the thing would be improved, and you would have no difficulty with our manufacturing confrères.

30183. I see you give a statement as regards the Almond Mill, that you have an effluent of 175,000 to 200,000 gallons in the twenty-four hours, charged with over 300 parts of suspended matters. I presume these suspended matters are mostly china clay and lost pulp ?—No; perhaps I might explain exactly what this is.

30184. Yes ?—This is an effluent, not the effluent we are turning into the river. These are matters that come away from our manufacturing processes, and which we have to deal with as best we may.

30185 Yes, I see ?—But of those 300 parts of suspended matters, there is a proportion certainly of mineral filling, but not quite so much as you might find in a better class mill, very largely dirty, gritty matters. They are very, very crude materials which we must use in this Almond Mill. As a matter of fact, there is no china clay used in the mill; they cannot afford to pay for it; it is a low class of paper. There is a certain proportion of mineral filling no doubt, but I would not like to say the bulk of it was that.

30186. Do you employ this apparatus for saving the fibre ?—In that mill we have strainers to strain off the fibre that comes away as far as it is possible to do so, but these 300 parts are not paper-making material at all, they are dirty matters of the nature of the waste material we use, and we have to deal with these 300 parts and take out as much of it as we can. We cannot use it again; it is too foul; we have to press it and cart it away at very great expense. There is no paper-making material in it or not any serious amount. I would just like, while you are on that matter, Sir, to point out that there is a small error in the capacity of our tank. Instead of 14,000 gallons it should read 16,800 gallons to be strictly accurate.

30187. Then do you pass all this 175,000 or 200,000 gallons into this small tank in one and a half hour's flow ?—Yes.

30188. It all goes through ?—Yes, it all goes through that tank.

30189. Do you find that that produces much effect in the settling ?—Oh yes, we turn out on the average about 20 parts per 100,000.

30190. That is after filtration ?—After sedimentation.

30191. After sedimentation alone ?—After sedimentation alone.

30192. Then most of it settles ?—Yes, the greater bulk of it by a long way.

30193. (*Mr. Tatton.*) You reduce the 300 to 20 ?—On the average it would be about 20.

30194. (*Sir William Ramsay.*) Then you filter afterwards ?—That sedimented matter is then in a liquid condition. We could not handle it anyhow. We have to press it into cakes by means of filter presses to make it more easily disposed of; we have to press it for carting. In any case we could not afford to cart liquid sludge, naturally.

30195. But then the effluent from that is filtered, I understand, or is it merely the fibre that is filtered, the sludge that is filtered ?—The sludge is filtered.

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30196. But not the effluent ?—The matter is sedimented in this tank and the overflow goes into the river.

30197. Without being further treated ?—Without being further treated,

30198. With its 20 parts ?—With its 20 parts. (*Mr. Potter.*) May I draw your attention to this ? These figures are ten or twelve years ago, 1898, and the average value of paper then was £8 1s. 4d. per ton; it is very much less now.

30199. I was going to ask the date; it is 1898 ?—It is 1898.

30200. The margin is still smaller now ?—The margin is still smaller now; in fact we are not making a profit at that mill now.

30201. So that any addition to the expenditure on purification cuts into the business very much ?—Well, it would then, because this mill is in the very centre of the town of Darwen. We had to pull down cottages to make room; I think we had to buy cottages; we certainly had to pull them down to put up the tanks, and to find room for the presses.

30202. Which made the land very expensive ?—Well, it made a great difficulty and added to the difficulties, of course.

30203. I suppose the statement referring to Hollins Mill that the water will average about 10 to 12 parts of total suspended matter means after settlement. This mill has an average effluent of 800,000 gallons of water per twenty-four hours which will average about 10 to 12 parts of total suspended matters per 100,000 of water and about 150 of total dissolved matters per 100,000 of water. That means after settlement in the way you have described ?—(*Mr. Hart.*) Yes, exactly.

30204. Do you find any use whatever for your sludge ?—No.

30205. It is simply deposited on the land, I presume ?—Yes. We have tried a great number of experiments and gone to considerable expense to try to make something out of our sludge. We could make a hydraulic cement from it but you cannot do it unless you have a very much greater output of waste material than we have. You want 100,000 tons. It would make a hydraulic cement.

30206. May I ask first, do you use esparto ?—At this time we used esparto at our Hollins Mill.

30207. Then, you recovered the soda, I presume ?—Yes.

30208. Then, part of your waste is carbonate of lime used in causticising the soda ?—Yes.

30209. That has to be carted away too ?—Yes.

30210. You bleach the pulp ?—Yes.

30211. And your spent chloride of lime is also carted away ?—Yes.

30212. Does the effluent from the bleaching process get into the river ?—It all passes together in our main effluent through the tanks before reaching the river.

30213. All mixed together ?—Yes. I need hardly say there is no spent bleach ever reaches the river; there is too much organic matter; it takes it all up. I might explain perhaps this point, that we have removed our esparto plant from this mill. This is what obtained in the year I was speaking about. We have removed our esparto plant from that mill.

30214. Do you still recover soda ?—We have no soda to recover at all; we have no causticising, quite an insignificant amount of soda is used for old papers.

30215. Is there any change in the law that you would suggest, would be advantageous from your point of view or from the point of view of the manufacturers in general; are you satisfied with it as it stands ?—We find there is no finality.

30216. You would like that there should be some sort of finality ?—It seems to me that the crux of the matter is this, that we are on comfortable terms at present with the authorities; we do not know how long it will last; we have spent a large amount of money; there is no finality; we have no guarantee. As we indicated in our letter here, we have come to a working arrangement but it can only be described as such.

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30217. It might be broken at any time ?—It might be broken at any time; we see no finality.

30218. Is it possible ever to have finality; the natural tendency would be to try to make the streams less and less offensive. All that, I think, could be possible would be that you would be left alone for a certain period of years, say ten, and then the state of affairs would be revised. I am not thinking of your trade alone, but of many others. One would require to legislate for many trades, not from one particular point of view, and in the case of the other trades, I think all that could be done would be to say: "Well, this appears a fair state of things for the present, we will allow you to keep going for five or ten years and then we shall have to revise" ?—Yes, but of course——

30219. I may point out that is what is done practically under the Alkali Act in connection with the escape of noxious vapours from chimneys ?—Yes.

30220. They put on a very easy limit, as they call it, five grains per cubic foot of acid in the escaping gases, and I do not suppose any manufacturer now turns out anything more than ·5 grains per cubic foot. It is found advantageous to recover, and he has also found it very little trouble and expense, and, as in your trade, it would become easier and easier as the processes for recovering it get known and other manufacturers make use of them, so one would expect in the course of time there would be an improvement. I quite take the manufacturer's point of view, that there should be no pressure at first, that we ought not to interfere with the existing state of trade or ought to interfere as little as possible ?—Naturally, you could purify the Darwen to hold trout as it did seventy to eighty years ago. But what is reasonable in this matter ? It seems to me that it should be possible, taking our mill for example, and taking the local conditions, what we can do as regards land and cost, for the local authority to say to us: "Well, now you are able to do so and so, we expect you to keep up to such and such standard: so long as you keep up to that standard you are immune from litigation." But supposing a change in the *personnel* of the Ribble Joint Committee, we do not know what would happen.

30221. Then, do you think the appointment of a Central Board would be the best remedy for that state of affairs, to which an appeal could be made, and from which you would get a perfectly impartial judgment. That has been the recommendation of the Commission, that there should be such a Central Board ?—(*Mr. Potter.*) May I say something on that ?

30222. Please do ?—We are very anxious to preserve our rights to go before the High Court. We have not been satisfied at all by the Board of Trade Inquiries when they have been held.

30223. (*The Secretary.*) The Local Government Board, you mean; it is not the Board of Trade ?—The Local Government Board. There is a gentleman sent down to inquire; naturally he could not be either expert or conversant with our business, and we much prefer to have our rights safeguarded, which we can now do by coming before the High Court of Justice.

30224. (*Sir William Ramsay.*) The proposal which was made by the Commission was that the Central Board should retain the services of experts who would be able to determine matters of fact, and the Courts would be simply used in order to try the cases as regards the law. Most of the money spent in litigation is spent in professional evidence and in arguing about that professional evidence by barristers. It would save a very large amount of the money if the facts could be taken for granted, if the facts could be returned by a Central Board which would serve as a basis for litigation, if you like ?—But our experience with the experts employed in our cases by the authorities has not been very satisfactory. They all came with *un parti pris* with a predetermined scheme of their own; we did not get impartiality.

30225. (*Mr. Tatton.*) Then, on the whole, would you rather have standards and work out your own salvation ?—(*Mr. Hart.*) Well, you are bound to have them sooner or later.

30226. Now, would not that press hardly in your particular case ? You are short of room at your works ?—Not if reasonable standards are adopted. What we are most anxious to retain in the Statute as it stands at present is that you must regard what is reasonably and practically available, using those terms in a commercial sense. In the litigation we had, Mr. Justice Bruce held that those terms must be naturally translated in a commercial sense.

30227. Then you mean to say that you would have a permanent standard fixed for your particular works, not a general one for paper works ?—Yes, exactly, and in taking that standard I maintain it would be necessary to have regard to what was possible to-day from the business point of view. It would be possible for one works to purify more than another. For example, if we had as much available land round our Almond Mill as we have at our Hollins Mill, we would be able to do more, and the determining factors would be what you are getting from your paper, the class of paper you are making, what is your margin of profit. When you have all these things to take into consideration, the manufacturer can say: "I can do it, or I can not do it."

30228. Would not that be rather hard on your competitors ? A competitor of yours might have plenty of room to put down purification plant, and it may not cost him very much more to treat his waste efficiently than it does you ?—Quite so, but there again you would come across the same proviso, what is reasonably and practicably available from a commercial point of view. In the case of this inquiry we were content to produce our books and show what we could afford to do in this matter. The proposal of the Ribble Joint Committee's Chief Inspector and Engineer, Mr. Naylor, who was the engineer, would have cut into our profits to the extent of 8s. 4d. a ton.

30229. (*Sir William Ramsay.*) Which would practically have taken away the major portion of them ?—Quite so. As Mr. Potter has already said, we have got our own inspectors, we have our own engineers, we consulted all the best men we could in the case of this trial. Our own expert in the vicinity here in Victoria Street promulgated a scheme which would cost us about £1,300 a year. We cannot do it; it cannot be done. You can close a mill, but you cannot purify the water to what some people would call a reasonable standard of purity. But we proved to the satisfaction of the Court that we did all we could, we did all we could be expected reasonably to do short of closing the mill. Of course it is a very difficult position to be placed in.

30230. (*Mr. Tatton.*) You would suggest taking each mill and having a sort of preliminary inquiry as to what they could afford to do ?—I cannot see any other suggestion that will ever land you into finality. You must have a standard. What is pure and what is impure are wholly relative terms. The paper industry is a peculiar industry in this sense that we require enormous volumes of water for the finished material produced, and the tendency nowadays is for that water to be increased. I daresay we are using 12 gallons of water per lb. of paper made. That means that you have enormous bulks of water to treat, and the impurities are more diffused, and it is a difficult question to solve. There is no nitrogenous matter as in domestic sewage, which is comparatively easy to precipitate. If you use precipitants it is very difficult to treat a paper effluent.

30231. Then you would have that standard fixed for a definite length of time; it would not be final of course for ever; so many years ?—So long as the conditions then obtaining prevailed.

30232. Supposing something better were invented, a better process ?—Then it would come up for consideration. I do not think you can legislate for all time.

30233. Then how would that differ from the present arrangement, that you have to use the best practicable and available means. Now each works has to use the best practicable and available means under the present law ?—That is so.

30234. Would it not be the same thing ?—If you have an initial outlay only. (*Mr. Potter.*) We have ancient outlets under Clause 4 of the Act, and that clause, of course, we are very anxious to preserve. And then we say, too, that the interpretation of what is reasonably and practicably available is one to be regarded from the commercial point of view.

30235. That is under the 1876 Act ?—Under the 1876 Act. (*Mr. Hart.*) Yes.

30236. (*Mr. Stafford.*) I see you are very strongly in favour of this Clause about best practicable means reasonably available ?—(*Mr. Potter.*) That is our protection.

30237. But you do not like any person to interpret on behalf of a Rivers Board ?—We like it to be interpreted by a Court of Law.

30238. But you have expressed here very strong opinions. You say :—

> "This in effect is what is actually done now in "Lancashire, but the policy of the Pollution Authori-"ties is non-committal, and is always uncertain, the "manufacturer, even if willing to do what is reason-"ably possible, is harassed and rendered hostile, the "maximum expense is thrust on him, and there is "no guarantee that such expense will render him "immune from legal proceedings."

Now that is a very strong statement. Could you give us something to show us what the Rivers Board have done to you ?—What has been done to us ?

30239. Yes ?—Well, I rather wish to avoid bringing forward any personal matter.

30240. Well, if you wish to avoid it why put a paragraph like that in your statement ?—Well, if you had been through the correspondence and the litigation that we went through for four or five years, with the Ribble Joint Committee, and been brought into a Court of Law, in which we won—it is a personal matter which I rather wish to avoid—but we went to the Ribble Joint Committee and offered to do what they had asked us to do and make some compromise. The answer we received was that the briefs had been delivered and had been drawn up. We could not do anything more ; we had to fight the case. We won the case, and it cost the county £3,000. As matter of fact, the brief was never used ; whatever the brief was it was never used ; they went into the Court on quite a different case. The case was never fought on the objections raised beforehand by the Committee, but it was fought on a mere question of expense, and everybody complained.

30241. Is it not rather a strong statement that the Rivers Board wished to harass you and wished to put you to an unnecessary amount of expense ? You first of all are in favour of the best reasonable means, but when it comes to a Rivers Board, who are the authority who are to say what are the best reasonable means, then you object to them. What would you put in their place ?—We are asking to be protected by a Court of Law.

30242. From the Rivers Board ?—From the Rivers Board, certainly. As a matter of fact we are not opposed ourselves to purification. We have spent very large sums, far more than appear from these figures—we have not put them in here because they are works we did inside our own business—and we have learned a great deal about our own business in consequence of having to look into the question of waste effluents. We have not been hostile ; on the contrary, we have taken the view that it was right for us to do all we could do. I have given the figures of £5,700, we have spent £10,000 inside our works. Because we saw a profitable return, we did not look upon those figures as figures we ought to give you: we have always tried to meet the authorities.

30243. Is this an expression of opinion from yourself or does it express the opinion of other manufacturers ?—It is our own opinion.

30244. Your own opinion alone ?—Yes.

30245. You have had unfortunate experiences ?—We have had a very costly experience and a very troublesome one, and for the last ten years, as I understand, Mr. Hart tells me, we have been at peace with the authorities.

30246. Now would it not be better for you to have a fixed standard than to have this reasonable means, leaving this to be interpreted by the Rivers Board or any authority that has to deal with the question ; it would be better for you to have a fixed standard for the whole trade ?—For the whole trade ?

30247. Yes ?—When you speak of the whole trade, do you mean all sorts of paper-making ?

30248. Yes ; all sorts of wall papers, for instance ?—We do make paper for wall paper, but it is paper-making pure and simple, and we make printings for the general trade also. A news mill has no effluent to speak of, but a mill making esparto papers or fine papers or rag papers has a very troublesome effluent.

30249. You think you could not have one standard for the whole trade ?—I am certain you could not. The effluent from a mill like Almond's, which uses refuse material, is very much worse than the effluent from a paper mill using prepared material like a news mill. The work is done in other countries. The chemical pulp comes ready prepared and goes straight into the beater.

30250. You object under those conditions to having this fixed standard ?—I say it is quite impossible.

30251. And you prefer to be left to fight your Rivers Board in a Court of Law without having an appeal to a Central Authority ?—I think so.

30252. It is an expensive thing for an individual manufacturer, legal proceedings in all these cases ?—In this case it was an expensive matter for the county.

30253. Well, but it might have been an expensive thing for you had you been beaten ?—Certainly.

30254. (*Mr. Tatton.*) With regard to the standards again, may I ask one more question ? Would it be possible to have, say three standards, say for the whole of the paper-making trade ; one for brown paper, one for white paper and one between the two ; could you come then within any of those three standards ?—(*Mr. Hart.*) Well, if every mill were similarly situated with regard to available land you might do so ; you might have a standard determined within very small limits indeed having regard to the class of paper being made and raw materials used. That is quite so, but what I want to point out to you is this, that when you have two mills making the same paper, or using the same raw materials, you should expect one to turn out a better effluent than another because he has the available means at hand. If you could imagine our Almond Mill, built as it is in the very heart of the town, in the centre of a very dense population, you would recognise we cannot acquire land except at a very high expense. That is the difficulty in making a general standard even for a particular class of paper, otherwise it would be quite feasible as you suggest. (*Mr. Potter.*) I might say something else about that. Take the case of esparto paper. You are speaking of white papers. Esparto is undoubtedly the best material, except fine white rags, for making paper. In practice, a ton of esparto gives about 40 per cent. of fibre, and the remainder of the esparto has to be treated as waste. A ton of chemical pulp is practically all fibre, and they both make white papers, so it is very difficult to apply the same standard to two mills, one using esparto, the other chemical wood pulp.

30255. In the one case you would have a recovery plant—you recover the esparto liquors ?—There is great washing process.

30256. (*Chairman.*) Thank you very much.

Mr. PERCY C. GREAVES, Mining Engineer of Wakefield, and Mr. ROSLYN HOLIDAY, Mining Engineer and the General Manager of the Ackton Hall Collieries, of Featherstone, Yorkshire, on behalf of the Mining Association of Great Britain, called in ; and Examined.

30257. (*Chairman.*) You have been kind enough to send us a proof of your evidence ; we shall be glad, if you have no objection, to put that bodily into our evidence, so that it will appear altogether ?—(*Mr. Greaves.*) Certainly. (*Mr. Holiday.*) Certainly.

(*Mr. Greaves.*) I am a mining engineer practising at Wakefield, and act as consulting engineer for a number of large collieries, the output from which is about 2,000,000 tons per annum

There are practically five effluents from coal mining as follows :—

1. Water pumped, or flowing direct from "outcrop" coals through adits.
2. Coal-washing water.
3. Coke-quenching water.
4. Spent gas liquor from sulphate of ammonia plants from coke ovens.
5. Water from the blowing-off of boilers.

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As regards No. 1. This varies very largely at each colliery, some pits being perfectly dry, whilst others have very large quantities of water to deal with. In one case a colliery with an output of only 50 tons per day pumps 1,161 tons of water, and in addition to this some 1,350 tons of water run out of the mine by gravitation; so that altogether this pit is dealing with some 50 tons of water for each ton of coal produced. I produce the following analysis of this water, from which it will be seen that it is very bad water indeed, and to impose any legislation calling upon the colliery company to treat this water, would be equivalent to shutting it up, and even then the pollution would not stop, because the water would rise and gravitate out of the mine.

Analysis of Pit Water Referred to.

	grains per gallon
Insoluble matter - - - - -	37·66
Peroxide of iron - - - - -	70·70
Lime - - - - - - -	38·44
Magnesia - - - - - -	17·24
Sulphuric acid - - - - -	140·00
Chlorine - - - - - -	6·30
Alkalies - - - - - - -	87·12
Total solid residue - - - -	397·46

This is an extreme case, but there are many collieries within my knowledge that pump from 5 to 10 tons of water per ton of coal raised. In some cases the water is very bad, but in others it is perfectly harmless. In new pits sunk to the lower and deeper seams this trouble is not likely to be met with, as most of them find the water in the shaft, and not in the workings, and this is tubbed off.

As regards No. 2. The effluent can be fairly easily dealt with, either by means of settling tanks or by passing the water through washed coal, and mixing the "slimes" with the small coal for coking, and this is done at practically all the collieries I am connected with.

3. The coke-quenching water can be dealt with by means of settling tanks, without much trouble.

4. This is the most difficult water to deal with, and there are several ways of doing it, though none of them are entirely satisfactory so far as I know. At some collieries it is evaporated at a considerable cost, by putting up a special plant, and using gases which would otherwise be utilised to raise steam, supplemented by coke breeze.

Other collieries use the water to quench the coke, but it gives the coke a dull appearance, and there is a difference of opinion as to whether the coke is worse to sell in consequence.

There are two chemical processes, one invented by Mr. Radcliffe, and the other by Dr. Grossman, but I believe neither of these systems is in use on a large commercial scale, and I believe there is no satisfactory system yet known how to deal with these waters. There are some new "Kopper's" ovens where the gases are not scrubbed with water, but passed straight into the saturator, and I am informed the spent gas liquor is reduced very largely in consequence. The Otto-Hilgenstock Company are putting down a plant in Scotland in which they say there will be no waste liquor. They have two plants working in Germany.

5. Much of the water used in boilers is very often pit-water, and is extremely hard, and leaves a lot of solids in the boiler, which must be blown out from time to time, but the effluent can be dealt with by means of settling tanks, without too much trouble.

(*Mr. Holiday.*) I am a mining engineer and general manager of the Ackton Hall Collieries of Featherstone, Yorkshire, from which the output is 800,000 tons per annum.

The effluents from coal mining can be divided under two principal classes:—

1. The natural water of the strata.
2. Effluents from various processes carried on at a colliery.

No. 1. This may be pumped or flow directly through adits. Both the quantity and quality vary largely at different collieries. In a number of cases there are many tons of water dealt with per ton of coal output. Should legislation impose upon the colliery company the treatment of such water, it would practically amount to the shutting up of the colliery, nor would the damage inflicted cease, as the water finding its way to the mines to the dip, would cause them to be closed, and even then it would rise and continue to flow by gravitation. These waters commonly contain peroxide of iron and sodium chloride.

No. 2. These consist of:—

(*a*) Water from coal washing.
(*b*) Coke quenching water.
(*c*) Water from blowing off of boilers.
(*d*) Devil water from sulphate of ammonia plants.

(*a*), (*b*) and (*c*). The solids in suspension in these effluents can be dealt with at a not excessive cost by means of settling tanks, or in the case of (*a*) by passing the water through the washed coal, though the resulting dull appearance detracts somewhat from its selling value. In confined areas where the land surface is flat, the settling tank treatment is considerably higher in cost.

(*d*) This effluent is the most difficult to deal with, and I know of no perfectly satisfactory method.

One process consists of evaporating the water, special plant being erected, and gases which would otherwise generate steam being used to supply the necessary heat, the lost heat being made up by an extra consumption of coal. This process is very costly.

30258. You both have very large experience apparently of coal water?—(*Mr. Greaves.*) I may say we have both had a good deal to do with coal water.

30259. Coal water, if it once got into a river that was used for drinking purposes, would spoil the river completely, I suppose?—Some waters, not all.

30260. Is there any coal water that could go into a river that was used by people to drink, without spoiling it?—Well, I have a case now where the water that comes out of a mine is used by the people living close to the mine for the purpose of making tea; they say it makes excellent tea.

30261. (*Sir William Power.*) Some coal water is used for public water supply purposes in Durham, for instance?—I believe in Durham, but I do not know of any in Yorkshire.

30262. (*Chairman.*) In the case which you refer to, where they use it for making tea, do you mean that the coal water itself is used for the purpose of making tea?—The water that is pumped out of the mine is used by the people who live in the cottages close to, for the purpose of making tea in preference to the town's water which is laid on.

30263. (*Sir William Power.*) That is not the water from the workings, that is the water encountered in sinking the shaft, is it not?—There is practically no water in the workings, it is the water in the shaft itself.

30264. (*Chairman.*) This is what you have described in your paper as No. 1?—No. 1, that is so.

30265. Of your five descriptions, No. 1 can be used to make tea. Then No. 2 is coal washing water, No. 3 is coke quenching water, and No. 4 is spent-gas liquor from sulphate of ammonia plants from coke ovens, and No. 5 is water from the blowing off of boilers. Are those four equally noxious?—Oh, no, my Lord, I should say No. 4 is the most noxious, very much.

30266. The spent gas liquor?—The spent gas liquor.

30267. Have you made any experiments in treating that spent gas liquor?—No actual experiments. We put it on to burning waste heaps and tried to do the best we could, and we have made very little of it. Practically, so far as I know, there is nothing can be done with that water except using it up by quenching the coke and turning it necessarily into steam.

30268. You mentioned some new experiments that you have heard of, but of which you cannot speak from practical experience?—Only from discussions with the manufacturers of the plant.

30269. As far as the law goes, under the Rivers Pollution Act, collieries are exempt from many of the provisions?—Only so far as regards water that they pump out of the mine. If they use the water for manufacturing in any way whatever, then they become liable to the Rivers Board, I have always understood.

30270. (*Sir William Ramsay.*) I suppose that the coal-washing water is generally recovered and used over again is it not?—Practically always I may say.

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30271. And that lasts for a very long time, in fact, there is no deleterious waste from that at all ?—There is a slight waste, but it is nothing to mean anything, and from an economical point of view I think it is desirable to use that water over and over again. You get a very fine dust which is good coal really, you collect it and mix it with the other smalls and pass it into your coke ovens and it cakes, so it becomes coke.

30272. And the water is practically clear ?—Practically clear.

30273. Are you aware that that process is not used in South Wales ?—I was not aware that it was not used in South Wales.

30274. The coal-washing water goes all into the rivers and makes the bottoms perfectly black and the waters perfectly turbid ?—I should have no objection to their seeing mine.

30275. There is not the slightest possible attempt made to collect it ?—Indeed.

30276. We had evidence in South Wales that they are very lax in that particular; they waste their coal washings ?—I pump the whole of the water, after washing, together with the coal, into large tanks. These are square tanks, steel supported, and let the coal do the filtration to a very large extent; in fact, 90 per cent. of the filtration is done through the coal itself. And the same remark applies to the dirty water; the water which takes away the dirt; the water is there filtered through the fine dirt.

30277. So that really gives no trouble. As regards No. 1 then, you are not responsible ?—We are not responsible to-day, Sir.

30278. Then, as regards No. 3, the water which is used for quenching coke, if it is the mine water, it leaves the coke not dirty, does it, or is there settling required after that ?—There is a settling required after coke quenching, because there is a certain amount of small coke gets on to the bench, very fine indeed, and is washed away with the water, and that wants settling just the same as the coal water.

30279. You use that water over again ?—Oh, yes, quite readily.

30280. As regards No. 4, I notice you say that other collieries use the water to quench the coke, but it gives the coke a dull appearance, and there is a difference of opinion as to whether the coke is worse to sell in consequence. Is that a real complaint, that the coke is duller, not so good for its purpose, iron and smelting purposes ? —It is a real complaint, and how far it is well founded or not, I could not say, but some buyers will say that this coke is rather of a grayer appearance.

30281. It is ?—One can readily understand there is a large amount of lime in the spent gas liquor that must necessarily be deposited on the coke. But as against that, lime is generally added in the blast furnaces, so that I do not think it is a very great deal, though you know what a customer will say; he compares your coke to that of your neighbours, and if it is slightly different in appearance he must have so much a ton off the price in consequence.

30282. The amount of this gas liquor, compared with the whole of the water used for quenching the coke, is very small. You require far more water to quench the coke than the gas liquor you produce ?—Oh, much more, I think, certainly.

30283. So that it is a comparatively small thing ?—Well, it is a fair lot too. It takes about a ton of water generally for a ton of coke, and I should not like to say the proportion now, except as a guess, but I should say it would be nearly 40 per cent.

30284. What I mean is, supposing you produced so many tons of coke, could you not dispose of all your gas liquor easily in quenching the coke you produced, if you use no other water ?—Oh, yes; you would use more water.

30285. You would require to use more water than the gas liquor you produce ?—Yes.

30286. So that is a feasible way of getting rid of it ?—It is a feasible way, but you have the difficulty of colouring the coke, if I may term it that way, and the waste that runs out goes into your coke quenching water waste, and that would have to be dealt with again, though I think it is a feasible way, if the steel manufacturers did not object to it; but if they have a fear of the coke being injured in any way they simply will not deal with you.

30287. Does the fact of making coke in bee-hive ovens, or in other ovens, make much difference; you require to quench them both ?—Yes, exactly the same, only in the one case it is quenched inside the oven and in the other outside.

30288. And does the same remark apply to both processes of coke, as regards deterioration in colour ?—I have never known a by-product plant used in connection with a bee-hive oven, though I believe there are such plants, but I know of none.

30289. Then the other method of disposing of it is to turn it on to a burning heap ?—Yes, Sir.

30290. Are all collieries provided with burning heaps ?—I am sorry to say most of them, but not all.

30291. That disposes of it very thoroughly, I suppose ? —It evaporates it, there is no doubt about that.

30292. Has the ordinary process of filtration been tried upon such effluents ?—Oh, yes, but it is no good at all.

30293. Of course, no bacterial action will take place ?—No, it would destroy anything of that kind.

30294. But on the other hand, is there not an absorption of soap, the tarry matter, which is the real question of complaint ?—I do not think there is any tar in this effluent at all. It is a yellow water without any tar so far as I know, but it is absolutely destructive to all vegetation. You get it on to the ground and that ground will not grow anything for a great many years.

30295. No, but does it not contain phenols ?—I believe it does.

30296. Has any attempt been made to recover those ?—The only attempt I know, is that system of Dr. Grossman's and it has not gone very well.

30297–8. Is that in the experimental stage still ?—I think it is in the experimental stage still. They have not made it go in the colliery; it has been a failure up to now as far as I understand.

30299. That has been tried in Scotland ?—That is being tried in Scotland and I understand there will be a plant early next year in work there.

30300. I have read the description of the German plant and it sounds very feasible ?—It sounds very feasible; it is quite a new idea.

30301. As regards the boiler water, from the blowing off of boilers, that, of course, contains a very large amount of sludge. There is no difficulty whatever in settling or filtering off that sludge ?—I see no difficulty whatever if you provide tanks and clean them out regularly.

30302. (*Mr. Tatton.*) With regard to No. 1, the water pumped or flowing direct from the colliery workings, is not the water pumped at certain times much worse than at other times ?—I do not think so, Sir. I think in many mines it is a very regular flow, except that it is rather greater in quantity in winter than in summer, especially in those mines which are nearer the surface, but it does not vary materially.

30303. Do you pump from a sump as a rule ?—Yes, nearly always.

30304. You have a sump at the bottom of your shaft ?—Take the case that I gave you with that very bad water; there are two levels, one out two miles in one direction, another about a mile and a half; the water collects at those levels and runs gradually to the pit bottom, is there taken by the pump and lifted to an adit where it runs out to the day.

30305. Does not that sump eventually get filled with a good deal of solid matter and iron ?—It gets filled with solid matter, but it is cleaned out once in six or twelve months. It is a very dirty job. There is no difficulty whatever in cleaning that sump out.

30306. When you clean that sump out, do you not pump that water out into the stream ?—You pump the water out as far as you can and simply scoop the half solid, half liquid matter into tubs and put it on to your waste heap.

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30307. You take that clear away ?—Clear away, yes.

30308. And you have not any dirty water, as a rule pumped out ?—Well, it is necessarily very much disturbed by the operation of scooping the solids out, and it will probably be a little worse the first quarter of an hour after resuming pumping.

30309. Would it not be possible to run that water at these periods into some settling tank ?—I am afraid you could not get a tank big enough ; I mean it would be an enormous tank to take that very large quantity of water ; it would be an enormous tank. That would require to be run in for half an hour, and, even then, I question whether you would do very much good.

30310. You would have too large a volume actually from the sump itself to treat ?—Yes, because in many cases you could not go more than a quarter of an hour without pumping again, your sump would fill up.

30311. I happen to know one case—that is why I ask this question—where periodically there is very serious pollution from this colliery when the sump is cleaned out. Ordinarily it is perfectly right ?—I do not know of any water that has sufficient solids in it, if I may say so, solids that would deposit in a sump. I think with the continual pumping it would only leave the larger pieces in, pieces the size of one's finger nail, and a little bit less, but not much less ; all the other would go away with the actual pumping, all the small ; there is such a big flow of water that it would be carried away by the ordinary pumping method.

30312. Have you got iron in your collieries, is there much ochre water ?—It is ochre water that I am referring to.

30313. Does not that settle in the sump, thick yellow stuff ?—It comes out mixed with the water the whole time, the water is always ochery.

30314. It is always ochery ?—It is always ochery. I know mines in the same district where they have given over pumping and the water is running out quite yellow now to-day. It has been stopped to my knowledge fifteen years and it is running out quite of an iron colour still, as it is called locally.

30315. (*Sir William Ramsay.*) But clear of course ?—Yes, fairly clear, but it deposits the ochre on the sides of the bank.

30316. As soon as it comes out ?—As soon as it comes out.

30317. Might I ask, are these parts per 100,000 or grains per gallon which you put ?—These are grains per 1,000 gallons.

30318. Grains per gallon surely ?—These are grains per gallon, Sir, you are right.

30319. (*Mr. Tatton.*) What about the drainage from the workings ; in cases where you have very little water to pump away does all that go down to the stream ?—Yes, Sir, it all goes down to the stream.

30320. And with regard to this water, which makes this good tea, how many men have you employed in the works, in the colliery ?—Oh, there are 800 men there, but of course with regard to this water there is no one working there. The shaft is 150 yards deep ; the water was found or collected about 70 yards, about half-way ; the water very gradually drains into what is known locally as a launder or small cistern, and the pump pumps out of it and it is perfectly clear, beautifully clear water.

30321. Then the drainage from the works does not go into it ?—The drainage from the works is at a lower level, a 150 yards level, and this is at 70 yards level. Most of the water is collected at 70 yards level ; I should think only 20 per cent. of the lot is made at the 150 yards level.

30322. And that is pumped to a different part ?—In pumping they pump all the water to the top, but when the workmen want the water from the mine for domestic supply they simply go down to this launder and collect sufficient water for their tea.

30322. And that is pumped to a different part ?—In pumping they pump all the way to the top, only when acid in it.

30323. It afterwards all goes together ?—It afterwards all goes together.

30324. (*Sir William Ramsay.*) Is the water acid, one could calculate it, of course, but has it free sulphuric acid in it ?—There is free sulphuric acid in the one I have given the analysis of ; it is very acid indeed ; it eats the pipes and the pumps and everything.

30325. (*Mr. Tatton.*) You speak of certain water being tubbed off. In new pits you say, sunk to the lower and deeper seams, this trouble is not likely to be met with, as most of them find the water in the shaft, and not in the workings, and this is tubbed off. That is to say, you lift it up in tubs, I suppose ?—No, Sir. They sink the shaft and they find the water in the strata, so far down, they line the shaft with cast-iron tubing like a caisson. The modern practice is not to deal with the water at all, but if that water is near the coal seam it is no use tubbing it off. Directly your first weight of breaking of the strata takes effect the water will run into the mine itself, and your tubbing of the shaft does no good whatever ; but in the deeper mines the water is somewhere near the surface, the seam itself a long way from the water bearing strata and it would require a very great weight or breaking of the strata to let the water through to the seam itself, in fact it very seldom occurs.

30326. You keep it out altogether ?—I know certain deep shafts which have no pump in the shaft at all. They have water in the strata, but no water in the mine of any description, and they actually tap the tubbing to take water down into the pits for the purpose of watering the horses and watering the roads.

30327. With regard to No. 3, this coke quenching water, what is there in that water ; is there solid matter ?—There is a certain amount of solid, not a great deal, a certain amount of solids, very fine coke.

30328. Does it settle out fairly easily ?—It settles out fairly easily if you have a big enough tank.

30329. There is nothing else in it ?—Nothing else at all.

30330. Do you know anything about the Otto-Hilgenstock process ?—Only by discussing it with the Otto-Hilgenstock representative, that is all.

30331. You have had no experience of it ?—I have had no practical experience of it.

30332. (*Mr. Stafford.*) This No. 1 water damages the rivers ?—I believe No. 1 water does, especially where you get a bad case such as I have given you there.

30333. That analysis is very bad ?—Yes, it is very bad.

30334. Could not anything be done to improve the condition of this water ?—If you are to do anything at that particular mine you would shut it up and the water would continue to flow through the strata just the same as ever. It would be only a question of a very few weeks when it would begin to rise and flow into the river just the same.

30335. Why would you shut it up ?—It is only a small mine of 50 tons a day. It is just about making ends meet now, making a very small profit. They would not go to very much expense. A very large quantity of water like this would necessarily mean a big expense in dealing with it.

30336. May we take it, this is a very unusual case ?—I am bound to say this is the worst case I know ; it is on the River Don.

30337. And a very unusual one ?—So far as quantity and quality are concerned, yes ; but there are a good many cases where the water is bad, ochery, but none so bad as this one.

30338. Then that No. 1 water is a serious damage to the stream ?—Undoubtedly so.

30339. And where it can be treated it ought to be treated ?—If it could be treated, at anything like a reasonable cost, I should say certainly.

30340. Why can it not, under ordinary circumstances, be treated at a reasonable cost ?—Well, I do not know any process that will treat this at anything like a reasonable cost. I am afraid it will be a very difficult thing to treat this water.

30341. What are the difficulties ?—I understand it would cost a lot of money chemically to treat this water and get rid of the sulphuric acid, your volumes are so very great.

30342. (*Sir William Ramsey.*) And it really, after all, would be treating a natural water ?—It would be treating a natural water, Sir.

30343. The cost of which should not be thrown on the mine-owner ?—And if you stopped working it would go on.

30344. (*Mr. Stafford.*) Have any experiments been made for treating this water ?—I think in the past they tried various things to try and save their pumps, because it damages their pumps to the extent that every few years they have to be renewed, and so far as we know we do not know anything, at any reasonable cost, that would deal with it.

30345. (*Chairman.*) Then may we take it from your experience that you consider this very exceptionally bad water ?—It is the worst I know.

30346. Then the best you know is that of which the people make tea ?—That is so.

30347. And of most of the waters with which you are connected, to which do they most approximate, the very best or the very worst ?—Oh, they most approximate to the best.

30348. To the best ?—I should think there is a very large number, a larger number of good waters than bad waters.

30349. You would say that ?—A larger number of good waters than bad waters.

30350. Very much larger ?—Very much larger.

30351. Is there anything you would like to add (*Mr. Holiday.*) No; there is very little. One might have amplified one or two things that Mr. Greaves said, but I did not know whether you would see me after Mr. Greaves or at the time.

30352. We shall be delighted to hear anything you have to say ?—I have said in my evidence that with regard to the treating of the coal-washing water that is much more expensive where it has to be done in confined places or on land that is flat. It is easily done in collieries that are on the slope of a hill, because the refuse from the washer is formed into a sort of reservoir. They keep tipping it round in the form of a reservoir, and the dirty water is often run into this form of reservoir and the water drawn away, leaving the slurry which can be used for firing boilers. But in districts of confined space you cannot do that, and in the place that I am connected with, we have just a large excavation, an old track to the clay hole. We have had to build a quay wall right across the middle of it with two pairs of rails on the top and run the water alternately into one side and the other. When one side is filled we take a steam dredger and steam enough in and fill the one into trucks in use while the other side is being filled up again. Then another difficulty that one encounters with regard to the coke quenching water—Mr. Greaves mentioned that he had come across that—is that in many places where there is not enough water for use for the colliery if the devil water, as it is called, the ammonia liquor, is put on to the coke, although you have to use a ton of water per ton of coke for quenching purposes, the whole of that is not evaporated; you must put considerably more water than is actually evaporated in order to cool the coke in order that it does not fire through the heat being exposed to the atmosphere, so you have a considerable proportion of the quenching water which always passes into the drains, so if that goes into the drains, while you use your own water for the boilers, you are suffering very heavily indeed. That is one of the difficulties in using it for coke quenching purposes that so much of it runs away and goes into the drains. I do not know that there is any other matter; Mr. Greaves has dealt most fully with them, and our experience is almost identical in these matters.

30353. (*Sir William Ramsay.*) There is only one other point I should like to ask you, and that is as regards the position that the colliery owners are in in connection with the law. Have there been any prosecutions ?—(*Mr. Greaves.*) I have known prosecutions, Sir, with regard to the devil water or the ammonia water, but I have known no prosecutions with regard to the water out of the mine direct. I have known several threatened, but nothing ever came of them.

30354. Is there any feeling of unfair usage that one mineowner has been prosecuted and his neighbour not ?—No, Sir, I am not aware of that.

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30355. I suppose this is a useless question to put, but I will put it for completeness sake. It is never possible to put such waters into the sewage drains and lead them to the ordinary domestic sewage purification plant ?—(*Mr. Holiday.*) It is possible but the local authorities would not allow us to do it.

30356. I should have thought that collieries were so rarely in connection with ordinary sewage purification plant; you would be some distance off ?—Oh, in the villages; some of the collieries, some of the older ones, the villages have grown up round the colliery and the sewage works are close to. In the district I am in there is a number of sewage works and collieries in close conjunction, but they would not allow the water to be turned into the drains.

30357. Is there much suspended matter in this devil water ?—No. I have very little experience of the devil water, Mr. Greaves can speak more authoritatively than I can. (*Mr. Greaves.*) I should say it is lime in solution, practically speaking, I think there is very little solids indeed; little could be filtered out; it is nearly all in solution. (*Mr. Holiday.*) With regard to the water that is pumped from the mines, you asked about prosecutions, whether any prosecutions had taken place. I might say that in many cases prosecutions have been threatened. The landowners and farmers have complained that it was bad for their cattle; they have seen a different coloured water and they said their cattle would not take it. But time has gone on and no prosecution has taken place, and they have got quite accustomed to it, and now they say nothing about it. That only arises in districts where collieries are newly started or water is found. Our own pit ponies drink it without harm. Although it is not very nice water it is only the sight of it. Where ochre is deposited in the pits the farmer says it injures his cattle, but that has passed away.

30358. It strikes me there is a possible use for that water, I do not know that I shall be thanked for suggesting it—it is this, that after the authorities have purified their ordinary domestic sewage, this devil water might be used for destroying bacteria before it goes into the river. There is not very much of it and it is conceivable that it might be useful in that way ?—(*Mr. Greaves.*) I think it would effectually destroy bacteria. (*Mr. Holiday.*) And everything else.

30359. (*Chairman.*) Do you know of any cases where a colliery has wished to send this water into the sewers and the local authorities have refused to receive it ?—(*Mr. Holiday.*) No, My Lord. I never heard of a case. In nearly every case a colliery is somewhere near a stream and they have turned it into the stream straight away. I may say that in the particular colliery I am connected with, the water did go into the sewers, and when the local authorities found it out they made us change it on the ground that theirs was a sewage plant where they had to pump, and it meant they had more water to deal with. They preferred that it should go into the surface drains.

30360. They made you pay for it ?—They made us alter it and turn it into the surface drains.

30361. You mean they refused to let it come into their sewers at all ?—It found its way; I do not know whether it was through a fracture—the line of their pipes and ours crossed, and our water got into their drains and was running for some time. When they found it out they made us turn it into the surface drains to go down into the local stream so as not to go into their drains. They did not want to think themselves even bound to deal with it.

30362. (*Sir William Power.*) They refused it on account of its bulk, not of its quality ?—Its bulk, yes.

30363. (*Mr. Tatton.*) Do cattle get used to it; in this particular instance they did drink it ?—Oh yes, our own pit ponies drank it.

30364. Do cattle drink it ?—Oh, yes, right down the stream.

30365. They do not find some other supply ?—No, they are drinking it now, only the farmers do not like the appearance of it.

30366. Is it yellow ?—Yes, it is yellow and it has a saltish taste.

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30367 (*Mr. Stafford.*) Is there a danger to the cattle that drink this ?—I think I should say not, because we should have had to pay for them if there had been. The farmers would have been very ready to claim for damaged cattle if it had injured them.

30368. Would you be ready to pay for them ?—Of course, if they proved it.

30369. They would have to prove the injury ?—Yes.

30370. (*Chairman.*) Thank you, we are very much obliged to you.

NINETY-SIXTH DAY.

Friday, 29th October, 1909.

PRESENT:

Colonel T. W. Harding, J.P., D.L. (*in the Chair*).
Sir William Ramsay, K.C.B., F.R.S.
Sir William H. Power, K.C.B., F.R.S.
Mr. T. J. Stafford, C.B., F.R.C.S.I.
Mr. R. A. Tatton, M. Inst. C.E.
Mr. F. J. Willis (*Secretary*).

ALSO PRESENT:

Dr. A. C. Houston.
Dr. George McGowan.
Mr. C. C. Frye.
Mr. G. B. Kershaw.

Mr. Lewis Evans, J.P., F.S.A., Vice-President of the Paper-Makers' Association of Great Britain; Mr. Roland Green, Managing Director of Messrs. Thomas & Green, Wooburn Green; Mr. John E. Jepson, Director and Manager of the Star Paper Mill Co., Feniscowles; Mr. Tom Taylor, A.M.I.M.E., Manager of Messrs. Olive Bros., Ltd., Bury, Lancashire; and Mr. Edwards, Secretary of the Paper-Makers' Association of Great Britain, called in; and Examined.

Mr. Lewis Evans, J.P., F.S.A., Mr. Ronald Green, Mr. John E. Jepson and Mr. Tom Taylor, A.M.I.M.E.

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30371. (*Chairman.*) Gentlemen, I understand that you represent before us to-day the Paper-Makers' Association of Great Britain ?—(*Mr. Evans.*) Yes.

30372. And that your Association includes paper-makers in different parts of the country, not in one district only ?—No, the whole of England, Wales, and Ireland, but Scotland has an Association of its own.

30373. Now, how many firms are included and represented by your Association approximately ?—117, about.

30374. And may we take it that that represents the great bulk of the paper-makers of the country ?—Yes, certainly.

30375. In connection with paper works the characteristics seem to be that you require a large volume of water, do you not ?—The circumstances of mills vary very greatly. The mills that do not prepare any of their own stuff, that buy ready prepared wood pulp from Canada or Norway and Sweden, and make it into newspaper without any treatment, either bleaching or anything else, except grinding it up and making it into paper, they require very little water relatively; they keep using the same water over and over again, and there is a very small effluent from it. Mills that employ rags require a great deal of water. The rags after boiling have to be carefully washed for a long period, and washing carries away all sorts of dirt and small fibres that are very difficult to settle out; and those who prepare their own esparto by boiling are met with the same trouble, and also they have very strong soda solutions that they have to recover as far as they can and use over again, and there is always a certain amount of alkali, a considerable amount of alkali, going out from mills using esparto.

30376. We may take it there is a general incidence to all these works, that with few exceptions the volume is large, and the polluting matter considerable ?—In all the mills making the better classes of papers, but in the mills making newspaper, which I think is represented by Mr. Jepson, I think the effluent is relatively small. In rag mills, for every ton of paper made the effluent may be as high as 150,000 gallons. In an esparto mill I know where water is very scarce—they use esparto, and a certain amount of this prepared wood—the effluent is 10,000. In my own mill, using rags, esparto, and some wood, but bleaching everything, it is about 30,000 gallons per ton of paper.

30377 In connection with the esparto, one of the chief sources of pollution has generally been removed by evaporation, has it not, for the recovery of the soda ?—Yes.

30378. Then in certain northern mills, have not plants been established, the effect of which has not only been to very much reduce pollution, but also to assist the manufacturer, in some cases actually to provide a profit to the manufacturer, by the withdrawal from these waters of fibrous matter ?—I think all mills recover all the fibre they can by various devices. There has been a great improvement during the last twenty-five years or so in catching fibre, and not letting it go into the rivers, from objects of economy.

30379. Then has not the pressure of Rivers Boards and Local Authorities been to some extent useful to the trade itself ?—I think that some of the things that have to be done are economically sound; some of them are in the nature of luxuries from a manufacturer's point of view. Certainly, some of the things which have been forced on paper-makers have been in a way remunerative.

30380. I suppose we may take that your Association does recognise that manufacturers have certain responsibilities to prevent, so far as it is at all possible, the pollution of the streams upon which they are placed ?—Certainly, as far as it is at all possible.

30381. And manufacturers recognise that it is necessary, even if the plant does not bring them a profit, to carry out works of this kind ?—Yes; that has been forced on the notice of some of them by legal proceedings.

30382. But that is a fact which is generally admitted ?—Yes, it is admitted.

30383. You suggest that the conditions of the paper trade are so various that an uniform standard for the whole trade would not be practicable.—Well, if it were low enough to embrace the mills using such materials as common rags and rope, it would be; but in the interests of purification it would be better to regulate the scale of purity required to the possibilities of the individual mill.

30384. Would your Association approve a simple standard which might limit for instance the amount of suspended matter in an effluent, its alkalinity or acidity, and so forth ?—I do not think any of us have been instructed by the Association to speak for the Association as a whole; we are selected as representative millowners who could speak on the subject generally. Personally, I have now no objection to such a standard. The Thames Conservancy require it from our mills, and we are able to meet with their wishes.

30385. I see that in your proof there is a feature which is somewhat new to me; I do not remember to have seen it urged before. You suggest that where plants and appliances are carried out solely for the purpose of purifying effluent, this plant should not be considered in any way to increase the value of the factory for rating purposes.—Yes, a great many mills have had to spend a large sum of money, and there is a tendency among rating authorities to look round and include every possible thing they can in the way of capital outlay, and to increase the rateable value on it, and as these works are distinctly unprofitable as a whole to the paper mills I think they ought not to be rateable.

30386. The carrying out of works of that kind may be considered as more or less a necessary incident to the particular business. It would be somewhat difficult, would it not, for a Local Authority to begin to consider in connection with their rating of a place what was and what was not profitable?—It is quite easy as regards new works. You can put up new works in a situation where you have no difficulty with the water, on the sea coast, or you can build them in such a way that you can readily catch all the effluent and treat it; but in old works a very great outlay is necessitated in many cases, and a mill that was doing what was sufficient at a certain time, having grown to a certain size, suddenly is met with a heavy expenditure which will benefit it in no way financially.

30387. (*Sir William Power.*) Can you cite any parallel indulgence in the matter of rates to that which you are now proposing?—Any parallel? No, I do not know of any.

30388. Precedent I mean.—No, I do not know of a precedent exactly, but of course the general rule for rating is based on what it will reasonably let at from year to year, and that is an impossible thing to arrive at in the case of paper mills.

30389. (*Chairman.*) I think it would be convenient at this stage if you would be good enough just generally to indicate the methods that are employed by paper-makers for the purification of their effluents.—Well, in the first case, in the mill itself, any clean fibres that may be of value in paper-making contained in the effluent are intercepted, either by very fine wire screens or by revolving filters, and fibres so retained are as a rule used again in the factory. In some cases, if the paper is of a very fine class, some portion of that is sold to brown mills. The main effluent of the mill, from which has been excluded as much alkali as possible by processes of recovery, goes into a series of settling tanks, and ultimately to filter beds

30390. (*Sir William Ramsay.*) Are the whole of the liquors mixed before they go to these settling tanks, or do you treat various liquors separately?—No, as a rule they are mixed before they go into the tanks; in fact some of the resulting matters help the settling. The presence of a little excess of alum and of the lime from bleach sludge in small quantities assist the settling. In fact they are added very often for the purpose of helping.

30391. (*Chairman.*) And what kind of results do you obtain by this precipitation?—The resultant sludge?

30392. I mean in both directions. Is the sludge of any utility, containing as it probably does a large amount of fibre, and what is the resultant liquid effluent?—The fibre contained is in most mills of no use for paper-making again, or for any other purpose, and the sludge has no value. We have to dispose of it, either by carting it on to ground, or putting it on waste heaps. It has no commercial value at all.

30393. And what kind of resultant effluent do you obtain?—I have got here particulars which I can hand in of samples. The Thames Conservancy people very kindly visit our mill periodically, and we at the same time take samples ourselves, and I can give you here particulars as to the grains per gallon of soluble solids and the suspended matter, between August 1907 and August 1909, inclusive. They were taken at thirteen visits. Should I read these figures out?

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30394. Are you proposing to read to us what you have passed to me?—Yes.

30395. I think it would be useful if you did.—In soluble solids, the average of these thirteen tests was 37 grains per gallon, the highest was 60·02, the lowest 24·36 grains. Suspended matter, which I should say is about half mineral and half organic, the mineral being clay, lime salts, and silica chiefly, and the organic being fibres, waxes, starch, resin, and so on, the suspended matter average is 3·58 grains. The highest that we have got recorded was 9·25, which was rather abnormal, it being a windy day, and there was a good deal of coal dust floating down in the water and settling out. The lowest is 1·87 grains per gallon. For combined chlorine the average was 3·62; the highest 8·20, the lowest 1·37. For sulphuric acid combined, the average was 4·01; the highest 11·38, the lowest 1·08.

30396. Now, what you have been giving us are analyses of samples taken by the Inspector of the Thames Conservancy?—Yes.

30397. May I ask whether the Thames Conservancy consider these results satisfactory from their point of view?—We have had no complaints from them at all; well, over this period. I do not remember any complaint of recent years at all.

30398. (*Mr. Tatton.*) Have they a standard; is there any definite standard?—I imagine they have a standard.

30399. But you do not know?—I do not know what it is; I cannot say.

30400. (*Chairman.*) All you have to go by is whether they approve or disapprove; you have no knowledge of what standard they have to guide them?—No, we have never reached it, I imagine.

30401. Now, where are the mills of your Association mostly situated? There are not many, I believe, in the South; they are mostly in Lancashire and Yorkshire?—In Lancashire and Yorkshire; and in Kent there is a very considerable number.

30402. So far as Lancashire and Yorkshire are concerned, they are subject to the inspection of the officers of the Rivers Boards of those counties?—Yes.

30403. Then what about Kent; what is the nature of the control there?—Some of them, I believe—perhaps you could answer that, Mr. Green. (*Mr. Green.*) Those that discharge into the Medway are free from any trouble at all, and there is no doubt that there there is a great deal more pollution than in other places.

30404. No complaint has been made? They are estuarial waters, tidal waters, I suppose?—That is it. It is so near tidal water that I suppose they accept it as tidal water. I believe the level of the river at Maidstone is about 8 or 9 inches above the ordinary tide.

30405. Then would the County Authorities take any interest in this matter in Kent?—I do not know that. I only know that they have no trouble. I used to live at Maidstone, but I have been away from there thirty-six years.

30406. Are the paper mills in Kent, all of them, so situated that they can turn their effluents into what is practically tidal water?—No, there are some on streams which discharge into the Medway, and other places.

30407. But has there been no complaint in these matters?—I do not live in Maidstone now, so I do not know, but I do not think there is much complaint. I know they do take a fair amount of trouble about their effluent, but they do not go to the trouble and expense that we who are under the direction of the Thames Conservancy do.

30408. Then apart from Kent and the Thames Valley, and Yorkshire and Lancashire, have you paper mills in other districts?—Oh, yes, very considerable. (*Mr. Evans.*) They are spread all over England; some in Devonshire.

30409. Can you give us cases which I have not referred to?—(*Mr. Green.*) Well, the Exeter district, for instance.

30410. Where are they situated there?—On the river, those that I know are.

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30411. On the tidal part of the river ?—No, I do not think it is tidal much above Exeter. (*Mr. Evans.*) They are above the tide.

30412. Do you know whether any difficulties have arisen there, and whether the County Authorities have taken any action at all ?—I have not heard so ; I have been connected with the Association for years, but I never heard of any trouble with any mill there. They may have had little complaints, but I do not know of any trouble. I know at one of the mills at Ivy Bridge, near Plymouth, they had to put in some tanks. In fact, I went down to see them some years ago.

30413. (*Sir William Ramsay.*) Supposing there were any trouble, would it necessarily come before your Association ?—Oh, no ; if the paper millowner thought he was being harshly treated it would, but normally we should hear nothing of it.

30414. (*Chairman.*) Then your Association is an Association formed for the general purposes of the business, and not by any means specially to defend manufacturers against actions in connection with trade effluents ?—No, we have no power by our Articles to defend actions.

30415. Then may I ask, has your Association devoted any attention to the solution of the problems connected with the treatment of the trade effluents in the paper trade ?—No, every individual millowner has been left to look after himself in that respect.

30416. Do you suggest to us that, speaking generally, it is practicable for paper-makers, by either processes of precipitation or filtration or both, to attain results which are satisfactory to the controlling authorities ?—Where they can get land, but these things require a good deal of space, and there are mills that I have heard of where they have had the greatest difficulty in getting land. If you go into Scotland and follow the Esk, you will find the difficulty that some of the mills there have been put to to find room for their filter beds, which, in many cases are far away from the mill.

30417. Are paper mills situated as a rule within urban districts, or in the country ?—As a rule—I do not know about Lancashire—in most parts of the country, apart from Lancashire, they are in the country, in the rural districts.

30418. In urban districts I suppose very often the effluents are received into sewers ?—I do not know personally of any instance ; I have heard of cases where they have tried to get them into the sewers and failed.

30419. Then, speaking generally, your effluents are effluents which go into streams ?—Yes. One great check, of course, is the fishery owners on these streams where there is not any active Rivers Board. There are, as a rule, either fishery owners or, what is much more critical, fishing clubs.

30420. Has it been found possible in connection with paper mills to so far withdraw from the effluents chemical matters which are likely to injure fish ?—I believe so in most cases. Of course, where you have a big mill on a small stream, I do not feel certain about it. It depends on the relative size of the stream and the mill.

30421. Now, do you wish to call our attention to any special feature in connection with the legal aspects of the case, so far as they affect your trade ?—The legal aspects ?

30422. Yes. I was asking you just now in regard to standards, whether you thought a standard might be applicable to the trade, and I gathered from your answer that you thought the special conditions of each mill should be taken into account, and also the special conditions of the stream into which the liquid was discharged ?—Yes, that is my feeling ; that if you made a standard that could be worked at all mills, it would be a needlessly low standard in respect of certain mills, and, further, I suggest that old-established mills should have rather more latitude than any mills that are put up in modern times.

30423. I do not know whether Mr. Tatton, who has considerable experience of the effluents from the Lancashire paper mills, would be good enough to ask any questions ?

30424. (*Mr. Tatton.*) If you had standards for each mill, how would you work that ?—Well, you would have to classify mills using rags and rope, I think, mills using esparto, and mills that were using prepared wood pulp only, and in those cases you might have to differentiate between mills that were bleaching wood pulp, and mills that were able to use the pulp unbleached.

30425. Yes. Then you do not mean that you would have a separate standard for each mill ?—Oh, no.

30426. But a separate standard for each class of paper which was made ?—For each class of paper.

30427. How many would there be ; would there be four or five, or more ?—I should think five at the outside ; those using common rag and ropes, those using rags, those using esparto, those using bleach and wood, and those not using bleach, I should think.

30428. In the case of your mill, does the whole of the waste water from the works go down to the settling tanks ?—Yes.

30429. Then how much of the esparto liquor do you pump back to the evaporators ?—We recover and use again a quantity varying from 83 to 85 per cent.

30430. (*Sir William Ramsay.*) You evaporate the first two washings ; that is to say, the original liquor and one washing ?—We bring the washing forward ; the fourth washing will become the third, and the third the second.

30431. You wash methodically ?—We wash methodically.

30432. (*Mr. Tatton.*) You pass it round, as it were ?—Yes.

30433. (*Sir William Ramsay.*) I think it would be still possible to answer the question as to how many washings are evaporated. Where do you stop ?—I think actually we evaporate the two washings, the boiling and one washing.

30434. That is what I supposed ; yes ?—The boiling and one washing.

30435. (*Mr. Tatton.*) And it is washed twice in the boilers or only once ?—We wash once in the boilers, and then we have a method which is not adopted in any other mills in this country. After washing the strong lye out of the boilers, we raise steam again and blow the whole mixture out into a washing vessel, where we wash by percolation through that all our esparto is blown out in that way, and we wash in separate percolation vessels.

30436. And then that goes direct to the tanks ?—That goes to the tanks.

30437. (*Sir William Ramsay.*) Then I presume you causticise with lime ?—Yes.

30438. And then you dispose of your lime waste by carting ?—Yes, we have a big waste heap, where the ashes and lime and bleach sludge go, and where our sludge from the settling ponds is pumped up also.

30439. (*Mr. Tatton.*) Well, would you say generally that it is reasonable that the whole of the wash passed from a paper mill should be treated, and go to the tanks ?—It ought to go through some settling ponds undoubtedly.

30440. You think that ?—Yes.

30441. Have you any mills on the Thame under your Association ?—Oh, yes, Fisher's Mill.

30442. And have they had trouble there with the authorities ? Have they got purification plant ?—(*Mr. Jepson.*) I have no knowledge ; I never heard. (*Mr. Evans.*) I do not remember hearing of it.

30443. Have you brown paper mills in your Association ?—Yes.

30444. Would their difficulties be greater than yours, for instance, in purifying their waste ?—In some cases I should think it would, but, on the other hand, they are able to use up nearly all the fibres they can catch.

30445. (*Sir William Ramsay.*) You filter your effluent, I think, afterwards ?—Finally, through an ash filter.

30446. Is it by streaming filtration ; is it continuous or streaming filtration ?—Yes, it is continuous.

30447. (*Mr. Tatton.*) If you classified the standards, if you had a classification, which mills would you put, I might say, at the lowest standard, where the difficulties are greatest ?—Well, my impression is that the brown mills would be the worst, but I have not had anything actually to do with brown paper-making for twenty-five years. (*Mr. Jepson.*) It is a very difficult effluent to settle from a brown paper mill.

30448. Can you tell us whether it is a question of the size of tanks in the case of a brown paper mill ?—(*Mr. Evans.*) Well, in brown paper-making, you have not enough soda to recover ; you cannot recover your soda if you use any, and you use lime and soda, and the warm alkaline solution containing a lot of dirt is extremely difficult to settle, and of course there is a good deal of washing required in some of the brown mills to get the fibre in condition to be used. I know it is difficult.

30449. I think you have not told us the size of your settling tanks. How do they compare with the daily flow ?—Well, I have put on the paper here particulars of our tanks. Our flow is about 45,000 gallons an hour, and we first of all run the whole of that flow over five tanks in parallel, giving a width of stream of about 84 feet. The first tanks are 5 feet 4 inches deep, and from those they pass to a second series of five tanks, 77 feet wide and 4 feet 6 inches deep. In theory the first set of tanks hold our effluent for an hour and forty minutes, and the second for an hour and eighteen minutes. Then the effluent goes through a succession of shallow tanks 3 feet deep, varying in width ; we can suit the width as we like by partitions in them, which contain the liquor for five hours fifty-two minutes in theory. Our total settling tanks contain 397,700 gallons, which in theory would hold the effluent eight hours and fifty minutes ; but in practice, owing to the effluent being warm and flowing on the surface of the tanks, also to a certain amount of deposit on the bottom of the tanks at all times, the actual time that it takes discoloured water to go through is from three to four hours. The first two sets of tanks, the two sets of five, we empty two a day, one in the morning and one in the afternoon, pump the deposited sludge up on to our waste heap, the subsequent shallow tanks are emptied at intervals when we find it necessary, and from the last set of tanks they flow into two filters with a surface area of 1,920 square feet.

30450. (*Sir William Ramsay.*) Do the filters require cleaning often, or do they remain efficient ?—They remain efficient for a very considerable time ; there is not much suspended matter.

30451. (*Mr. Tatton.*) They are coarse filters are they ?—They are ash filters, yes, coarse, and graduated up to fairly fine at the top.

30452. Have you any analyses of your waste water before it goes through the tanks ?—No, I have not ; it varies enormously. It depends on whether you are washing a common rag, or washing much esparto, or no washing going on, or emptying a weak bleach from bleaching tanks, and what the paper machines are doing. There are seven paper machines in the mill.

30453. (*Sir William Ramsay.*) Supposing brown paper is made and you cannot recover the soda, is the soda neutralised before it goes into the stream ?—In some cases. Most of the mills where they have effluent tanks add alum in some form—generally lumps of alumino ferric cake—into the water.

30454. Which would help to settle ?—Which would help to settle.

30455. And also to neutralise the soda ?—Yes.

30456. (*Mr. Tatton.*) Do you use any precipitant ?—If we find the settling at all difficult we put in lumps of alumino ferric cake ; we have not got them constantly there. Our chemist goes round the ponds when it is necessary. We use bleach dregs mixed in systematically to help the precipitation.

30457. (*Sir William Ramsay.*) Bleach residues ?—Bleach residues. It is partly mechanical the lime sinking the fine fibres.

30458. (*Mr. Stafford.*) I suppose most of your troubles arise really with the fishery people, owners of fishery rights on the streams ?—Well, we really have had only trouble with them, and the real trouble we had arose from the bursting of a tank in which we had weak bleach dregs, and then we agreed to an injunction that we were not to have our effluent worse than it was at that time. Well, we have very much improved it since then. We never have any trouble with them now.

30459. In what class of paper mills do you get the most injurious effluents for fish ?—Well, I do not know how far a certain amount of alkali is injurious to fish ; if it is you get that mostly from the brown mill. In most cases where I have known trouble with fishery societies it has been through some accident, bleach getting in accidentally. Occasionally it is put in intentionally, as workmen used to be fond of fishing with a bucket of bleach or vitriol. Resin size closes up the gills of the fish and kills them very rapidly, but they are all substances of such value that no paper-maker allows the weakest bleach to go in now. It is used over and over again, and weak bleach washing waters are used again for bleaching.

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30460. I assume that an intensely alkaline effluent from brown paper mills would be injurious to fish ?—I should think it would be.

30461. Have you had many complaints from brown paper mills ?—There are none on my stream.

30462. Perhaps your colleague, Mr. Green, may know ?—I do not know of any. (*Mr. Jepson.*) Trouble from brown paper especially ?—Yes, there has been lots in Lancashire.

30463. In connection with fishing ?—No, not on account of fishing ; there are no fish in the rivers there, where the mills are at any rate.

30464. I should not have thought there was much fishing in Lancashire ?—(*Mr. Jepson.*) Well, not where the mills are.

30465. There is no hope for the fish, I suppose, where there is a brown paper mill ?—No.

30466. (*Chairman.*) Just one or two more questions I should like to ask you. In answer to Sir William Power, you said there was no precedent that you knew for making allowances in connection with rating the buildings and plant used solely for the purpose of purifying effluents ?—(*Mr. Hanson.*) No, I do not remember any

30467. But I notice Mr. Green makes a suggestion which goes beyond that, namely, that the cost of the plant itself should to some extent be borne by the community. Would you say anything to us about that, Mr. Green ?—I fancy I suggested that they should be able to borrow a reasonable amount.

30468. I am going to deal with that in a moment, but with regard to this point of the community bearing part of the expense of the manufacturer, do you seriously suggest that that is practicable ?—(*Mr. Green.*) Yes, where an extreme degree of purity is demanded owing to local circumstances.

30469. Do you know of any case where a local authority has agreed to share the expenditure of the manufacturer for carrying on his business ?—No.

30470. You know that in Lancashire and in Yorkshire there is a great variety of trades turning effluents into the river, and so far as I know no local authority has ever agreed to any such responsibility ?—But is it not a fact that they do it indirectly where they accept the effluent into a sewer ?

30471. No doubt you are right there ; where they are able to take the effluent into a sewer, they are probably not only helping the manufacturer, but doing what is best in the interests of the community as a whole, and promoting trade in their midst, and many authorities have now agreed to take effluents into their sewers, provided the volume of the effluent is not too large in proportion to their domestic sewage ; but your effluents from paper mills are often exceedingly large in volume, and it many cases it might not be practicable to take them, and we have heard from Mr. Evans also that in many cases they are not situated in urban districts. The suggestion you make to us that the County Council should share the expense of the plant in the country places is novel to us. I was wondering how far you had met cases where the local authority was willing to do anything of this kind.—To my mind that comes in chiefly where the demands are what the manufacturer would call excessive, and where the difficulties of complying with them are also very great.

30472. Then Mr. Evans makes a suggestion that the capital required for carrying out works of purification ought to be available from Government or from the county authorities at small interest, and he suggests an interest of 3 per cent., and that the capital should be repayable in thirty years ; but do you think, Mr. Evans, that either the Government or a local authority would lend money under such circumstances ? The lending

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of money in that way to an authority which is there permanently is a different thing from lending money to a manufacturer whose business may fail long before the period is reached within which he has to pay back the money. Is that a practical suggestion ?—(*Mr. Evans.*) Quite frankly to begin with, some of us think that the Government and public authorities spend some of their money to less advantage than this would be spent. Beyond that, the authority lending the money would of course have a first lien on the property, and compared with the value of the property the amount required for this sewage purification must necessarily be very small; one-tenth of the capital value would be a fabulous amount to spend, and at the same time there are many millowners that I know who would have very great difficulty in raising a sum of £300, £500 or £1,000, to put an elaborate system of drainage and settling tanks into their mill.

30473. Would it not be a more practical suggestion that they should borrow the money from their bankers at possibly a little more than 3 per cent. if the business offered a fair security ?—But you will not get bankers to lend money on this method of repayment. It becomes of the nature of public works; it is not for the benefit of the paper-maker that this is done; it is for the benefit of the public.

30474. We note your suggestion, but I was anxious to get from you how far it was a practicable one; if any of your manufacturers had been able to obtain a loan of that kind from any local authorities ?—Well, we have no powers to demand it you see, and no local authority has power to lend it either.

30475. Well, Mr. Green says in the statement he has put before us "the chief guiding principle as to restrictions on effluents should be the health of the community," and he rather suggests that streams are there to carry away trade effluents among other things, but surely the need of manufacturers on streams must be considered also. If there is a paper mill, the effluent from that paper mill may injure the water in the river so far as its use is concerned by other manufacturers, and therefore must not something else be considered besides the mere question of injury to health. Ought you not to consider the rights of manufacturers below a mill ?—(*Mr. Green.*) Yes, to a certain extent, but it seems to me that you might have a manufacturer come to a district where he would require an absolutely pure water. It would not be fair for him to have the right to settle on that stream and to demand that every factory above should discharge an absolutely pure water into the stream. I think in the first place you must consider the right of priority, and in the second place what is reasonably possible in the matter of expense. I quite agree that all the legislation as to pollution, or the prevention of pollution, has done a very great deal of good, but when it is vague, or when it is unnecessarily harsh, it may produce very bad effects indeed. For instance, it is quite within the bounds of possibility that by undue, harsh, or extreme legislation, our mill might be absolutely closed. Now, that means a very considerable loss to the community.

30476. But have you met with any case where a mill has been absolutely closed in consequence of the action of any authority ?—Not for the pollution of the effluent, but from smell; there was one near Maidstone that was closed.

30477. Then, speaking generally, you do recognise that a manufacturer has responsibilities in regard, not only to the health of the people below him on the stream, but also to the uses that the water of the stream may be put to ?—Oh, yes, certainly.

30478. I notice that Mr. Jepson suggests that manufacturers ought not to be needlessly handicapped by expenses in connection with the treatment of trade effluents, because they are in competition with foreign manufacturers who are not subjected to exacting requirements as manufacturers are in this country. Mr. Jepson, do you make that statement with knowledge of the facts in regard to foreign manufacturers ?—(*Mr. Jepson.*) Yes.

30479. Is it a fact, for instance, that among the German or the French paper-makers they can turn any kind of effluent they like into a stream ?—I am thinking most of Scandinavia just now. I have that in my mind; many of them are on big rivers where there are no such restrictions.

30480. But are they really paper manufacturers, or are they pulp manufacturers ?—Both; the paper manufacturers I am speaking of just now.

30481. Then your observation refers chiefly to Scandinavia ?—Yes.

30482. Do you know generally what the conditions are in France ?—No, I do not.

30483. Do you not think it exceedingly likely that when those people know that considerable improvement in the streams has been brought about in this country by putting a certain amount of pressure on manufacturers, they will imitate that action ?—Oh, that is quite possible. As to France and Germany, in our particular trade, the competition is not from that quarter, so I do not know the conditions obtaining there.

30484. Do you, Mr. Evans, know the conditions of any leading paper mills in Germany or in France ?—(*Mr. Evans.*) Not as regards river pollution.

30485. Where are the paper mills in Germany mostly situated ?—I think all over Germany.

30486. There is no special district devoted to that branch of trade ?—No, nor in France; they are very much scattered.

30487. You are probably aware that both in Germany and France there is a considerable movement for the prevention of pollution of rivers and streams, both by trade effluents and by domestic sewage ?—Yes, I quite recognise that; they will follow this country.

30488. We should have been interested if you could have told us what the circumstances of foreign paper mills were ?—No, I have never spoken to them on the subject.

30489. I see that we have here this morning, Mr. Taylor, who is, I think, not a member of your Association ?—(*Mr. Jepson.*) Oh, yes.

30490. I should like to ask Mr. Taylor, whether, having heard what has been said by the gentlemen who are here as a deputation from the Association, he wishes to say anything to us in addition or in contradiction of what they have said ?—(*Mr. Taylor.*) So far as I have heard, the question has been about the disposal of the effluent from the mill, but you have not asked any of the witnesses where they get the water from to work the mill; that is the point.

30491. Well, explain to us in what way it is the point ?—In this way. Our mill is situated on a tributary of the Irwell, the River Roach, and we are dependent nine months out of the twelve on the river for our water. We take out the water from the river and we purify it and we turn it in as clean as the water in that glass (*pointing to water in glass on table*). I say the people that dirtied it ought to do that for us; why should we purify their water ?

30492. You are a paper manufacturer ?—Yes, a three-machine mill.

30493. And you must have pure water for your business ?—Oh, absolutely; it is useless as it is.

30494. And in a great many cases paper mills derive their water from independent sources, do they not, deep wells possibly ?—There are not very many Lancashire mills can do that, because the iron in the water soon stops them. There are coal mines.

30495. You suggest to us that in the interests of the manufacturers themselves every polluter of a stream ought to be called upon, as far as is practicable, to purify his effluent ?—That is so. As to the question of dealing with different mills and different trades on one stream, I say there must be a standard for the stream, not for different trades, because if you have different trades and the first mill on the stream turns in a bad effluent, he might ruin the whole stream, no one else could use the water; and if that stream, as our stream does, flows into another stream, how are you going to deal with the people on the other stream when our stream has ruined it for them ?

30496. And you are in favour of a standard which would apply, not only to a whole trade, but to a whole rivershed ?—That is so, and to every river affected by a river or tributary flowing into it.

30497. I was rather interested in hearing you say that you were able to take water from a polluted stream,

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and to so far purify it as to make it thoroughly suitable for the difficult purposes of paper-making ?—That is so.

30498. Now at what cost do you attain a result of that kind ?—It costs us about £1,000 a year.

30499. Would you explain to us the process that you adopt ?—We take the water from the river, and the river really is the effluent from a print works—a calico print works. They spoil the stream for the lot, and they are the second mill on it. It comes down all colours and it is very difficult to handle; but we find that by taking in from a weir head and bringing the water along and giving it plenty of time in the atmosphere, and treating it with lime and alumino ferric, we can deposit everything and make it as clear as the water in that glass. (*Pointing to water in glass on table.*)

30500. Do you happen to have in your mind any analyses of the water when you first begin to deal with it; can you tell us for instance how much suspended matter there is in it ?—I could not tell you.

30501. But it is discoloured ?—I can tell you you could not see through that glass filled with it.

30502. It is opaque; it is muddy ?—It is muddy.

30503. It deposits an amount of suspended matter ?—A tremendous amount.

30504. Is it acid or alkaline ?—Principally alkaline.

30505. Taking this water, you deal with it by precipitation you say ?—By lime; first of all we treat it by lime, and then about a quarter of a mile further down the stream we put in alumina ferric.

30506. Now what kind of result do you obtain ?—We get a clear water.

30507. And at what cost do you get it ?—At our mill it costs us £1,000 a year.

30508. (*Sir William Ramsay.*) You filter the water afterwards ?—Yes, through Bell filters.

30509. Do you let it settle first before you filter it ?—It does settle to a very large extent in the stream, and while we are bringing it along our private stream, and then we run it into a reservoir close to the mill and it deposits a lot of matter in that reservoir.

30510. And it is finally filtered ?—It is finally filtered, and after the filters it goes into the mill and from our effluent we take out, by means of a filter press, as much suspended matter as possible; and it is very profitable for us to do it. Then it passes along through settling tanks, over cinder filters, and I cannot at the present time allow that water to go into the river; I am going to bring it back and use it again.

30511. (*Chairman.*) Are you able, after using the water, to again purify it so as to make it as good as it was when you began ?—Yes, clean, and I take it back again.

30512. (*Sir William Ramsay.*) You pump it back into the reservoir ?—I am going to bring it back again cleaner than I took it out of the river.

30513. (*Chairman.*) What kind of paper do you make ?—We make white printings and cream-laids, and all coloured papers. One of the worst coloured papers to deal with is a geranium.

30514. Do you use rags ?—A few rags, but not in the way that Mr. Evans does.

30515. Then you would say that your effluent was not so difficult to treat as the effluent of some other mills ?—Not from a rag mill like Mr. Evans', because the flocculent matter in a rag mill is a difficult thing to handle. You cannot bring that down; it is a difficult thing to precipitate.

30516. (*Sir William Ramsay.*) I was going to ask Mr. Evans about colouring matter in the water. A great many manufacturers make coloured papers; indeed, most make, more or less, coloured papers ?—(*Mr. Evans.*) Yes.

30517. Are your effluents coloured too ?—As a rule we have not more than one machine, or at most two, on coloured paper, and the quantity of coloured stuff that goes forward is not very great. You catch all the water from the machine and use it over and over again as long as you can, so that there should not be such an enormous quantity of coloured matter even in a coloured paper mill.

30518. But it is quite possible, I suppose, to make use of the effluent from a coloured paper machine again; the colour does not affect another colour ?—Oh, as a rule it would; you want to start with a white; you would get much confusion if you have a varying colour in the water you use originally.

30519. Then, in that case, can you remove this colouring matter by this precipitation ?—(*Mr. Taylor.*) Yes.

30520. Every kind of colouring matter ?—It does not matter what it is. I find that the different acids and alkalis from the effluent, getting into the colour, will finally.

30521. (*Mr. Tatton.*) How much water do you use in a day ?—We use about 60,000 gallons an hour.

30522. 60,000 gallons an hour for ten hours a day ?—Twenty-four hours a day.

30523. Twenty-four hours, you work right through; 60,000 gallons an hour ?—Yes.

30524. (*Chairman.*) And when you said just now that the cost was £1,000 a year, was that simply the cost of purifying the water to enable you to use it, or did it include the cost of purifying the effluent after you had used it ?—No, the cost of purifying the water at first.

30525. What is the cost of treating your effluent afterwards ?—Well, it is very little to us. Of course, there is the land to be taken into consideration, but the treating of the effluent is a very small matter; it is only a question of emptying occasionally the sediment which is deposited in the tanks. About once every three months a couple of men a week at one tank will empty it.

30526. You say to us that in a mill like yours it is perfectly practicable, within reasonable expense, to purify the effluent to such a degree that the water can be used again for paper-making ?—That is so; I cannot contradict it, because you can see it in our river.

30527. I will ask you from your experience of the paper trade generally, do you consider it practicable for all paper-makers to obtain results of that kind at possibly larger cost, but still at practicable cost ?—Well, I have not much experience of a rag mill, but I should say yes, for a wood pulp mill, using nothing but wood pulp. We use a small quantity of rags, but for a rag mill I cannot say.

30528. You have no experience to enable you to express an opinion ?—No.

30529. (*Mr. Stafford.*) Do you get much sludge from your works; from your treatment ?—From the filtering of the water, before we use it, do you mean ?

30530. Yes ?—Yes; and that is just the point I would like to bring before you; we do. When we filter the water before we use it.

30531. What do you do with it ?—When we filter the water before we use it, when we wash out these filters, it is fearful stuff like mud in the street. I have taken it up with the inspector on one or two occasions. I think it is pretty hard for him to say, I must not put back into the river what I took out.

30532. Do you take much out ?—Yes, there is a fair quantity of mud comes out of it, and I want to put it back.

30533. What do you do with it ?—I put it back.

30534. You do put it back, regardless of the inspector ?—Yes.

30535. That is an easy way of disposing of it. Do you think that is a reasonable or fair thing to do for the people below you ?—Well, I do not, but still it was put there by the people above me.

30536. You are complaining bitterly of the people above you, but you are doing the same thing to the people below you ?—Exactly, but with their own water; not with my effluent from the mill. With my effluent from the mill, no; I will put that back cleaner than I took it, but what I filter out of the water, before I use it, I say you must have it back.

30537. Now do you think that your action, or the action of the print people, is the more unreasonable ?—Well, I do not think I am unreasonable at all; I am only giving you what you gave me. And my point is,

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that if I can purify that water then the people above me must purify it.

30538. But would you apply that to everybody ?—On the stream.

30539. Everybody ?—Yes.

30540. For instance, supposing you had a case in which you had a brown paper mill immediately above you, would you not very likely close that brown paper mill if you insisted on their sending down as pure an effluent as you were sending down ?—They must put it back as clean as they got it.

30541. But might not that very action close that mill ?—I do not think so.

30542. Then, it is not unreasonable to ask every trader in your paper trade to purify his effluent to the same extent that you do ?—As far as I am concerned it is not.

30543. (*Chairman.*) It is a mere question of expense ?—That is so.

30544. In your case, the expense is not great, but in other cases it might be considerable ?—It might be considerable.

30545. But you think it might be done in every case without that prohibitive expense ?—Yes.

30546. (*Mr. Stafford.*) Have you any experience of other paper mills ?—I was in a mill in the south, on the Medway. The last mill on the Medway is the Snodland Paper Mill. It was a five-machine mill until it was burnt down; now it is rebuilt it is a three-machine mill. The whole effluent from that mill goes into the river. They do complain about its going in, but they have got a hard nut to crack to say that it is a detriment to the stream. It is a tidal river. They cannot prove that it is a detriment to the stream, because the biggest fish in the river are caught at the mouth of the Creek. The fishermen come and fish there because they say the fish feed on the effluent brought from the mill. That was brought before a Commission some years ago by Colonel Holland. They tried to stop them putting the effluent in and it was proved by the fishermen that they all wanted to fish at the mouth of the Snodland Creek, the reason being that they found the biggest fish there.

30547. Do you think that your effluents generally improve the fishing in the Medway ?—I cannot tell you; I am simply speaking about the Snodland Mill. (*Mr. Jepson.*) With reference to the brown paper mills generally in Lancashire, they have the utmost difficulty in complying with the severe restrictions of the Ribble Joint Committee. The effluent that they have to deal with is not in many cases very large, and they could not afford the expense of putting down very elaborate precipitating tanks. Some of the mills have put down reasonable, what is considered by tradesmen generally reasonable tanks, and they have had the utmost difficulty in complying with the wishes of the Ribble Joint Committee. I think in cases like that, where the mill is small, and there is a main sewer available, that the Local Authorities ought to assist small manufacturers by taking that effluent into the main sewer, and being as lenient with them as possible. On these rivers in Lancashire and Yorkshire, that are given up to manufacturing, it is not a question of any fish at all about it; there are no fish in the stream at all, and the amount of pollution that goes in from the mills is nothing to be compared with the washings from main roads and things of that sort against which there is no restriction whatever; washing in thousands of tons of limestone and granite. Sometimes in flood times you can almost cut it with a knife, and then the inspector next day will come up to a mill; he has found a little fibre in a stream that would not fill a bucket, and he looks upon it as very detrimental. We think there is more sentiment in this matter of pollution on these dirty rivers than anything else. We certainly think that the river inspectors should be instructed not to be too exacting where there is a reasonable attempt being made to keep out the solids from the effluent.

30548. (*Chairman.*) Is there any point, Mr. Taylor, beyond those you have put before us, that you would like to mention ?—(*Mr. Taylor.*) Respecting brown paper mills, I sent the question that you sent to the Paper-Makers' Association, to twenty mills in Lancashire and said if they wished to answer it they could. The majority of them were indifferent. I spoke to the proprietor of one mill, a brown paper mill, and I asked him how they were situated. I said: "Have you any difficulty in pleasing the inspector ?" and he said, "No." I said: "Would you like the stream, when you receive it, to be as you can use it for paper-making with reasonable filtering ?" He said: "We would." I said: "Would you like to put it back as you took it ?" He said: "We can." There is no difficulty. That is a brown paper mill; Wilkinson's, near Bolton.

30549. (*Mr. Tatton.*) Could a brown paper mill put it back quite clear like that ?—I do not know. I asked him, could he put it back as he received it, and he said he could.

30550. (*Chairman.*) Does Mr. Evans wish to say anything to us in regard to the encouraging evidence which has been given to us by Mr. Taylor ?—(*Mr. Evans.*) I should like to agree with Mr. Taylor, but he is in that class of mill which I regard as the easiest in regard to purification. The news mills are the easiest; he is in the second class. Then you come to the finer print mills, then the rags, then the rags and the rope. He is in the second class. That is why I say, for mills of that sort, it would be judicious to have a different standard. Then that you would have a reasonable and practicable measure to impose on mills using tarred-ropes, bagging and so on. The same standard would be prohibitive in the case of those mills whereas it would be quite reasonable in the case of mills like Mr. Taylor's or a news mill.

30550*a*. Is there any other point which the Association think it important to put before us ?—Yes. They think that where factories are situated in districts rated for sanitary or sewerage purposes, the Local Authorities should be compelled either to take the sewage and effluent of the factory, or else the factory should not be liable for such sewerage or sanitary rate.

30551. Then finally, the opinion of your Association is that you recognise the responsibility of paper-makers to do what they can within practicable limits to purity their effluents, and you are able to tell us that good results have been attainable, and one of your number tells us that in his opinion they are attainable in all cases within cost which is not prohibitive ?—Yes, I am afraid in the case of rag mills and brown mills, using this class of materials which they use, it would be absolutely prohibitive.

30552. We thank you very much for your evidence ?—(*Mr. Jepson.*) Thank you.

Dr. CHRISTIE called in; and Examined.

Dr. Christie.

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30553. (*Sir William Ramsay*) (*in the Chair.*) In what way, Dr. Christie, are you connected with this process, may I ask ?—I am the Assistant Manager of the Otto-Hilgenstock Coke Oven Co., Ltd.

30554. In London ?—In London.

30555. Are they actual manufacturers; is the process being worked in London ?—No.

30556. But you are putting up plants in various parts of the country ?—Quite so.

30557. Would you mind, to begin with, giving us an outline of the old process and contrasting it with your particular plant ?—Well, under the old process the gases from the coke ovens are drawn off at a temperature of something like—well, of course, from the top of the oven, one cannot say, it depends on the time at which the gas is being evolved.

30558. But at a high temperature ?—In the hydraulic mains at something like 250 degrees Centigrade, and they pass generally, under the old principle, through a hydraulic main which is fed with tar and are then drawn through a suction main to the condensing plant.

30559. The object of the tar being to take out other hydro-carbons, I presume ?—Chiefly to clear the pitch away.

30560. To promote the condensation ?—Quite so. Then generally, one attaches water-coolers, air-coolers, etc. The gas is first passed through air-coolers where a quantity of tar is deposited and very little water. Then it enters the water-coolers, and is cooled by indirect contact with water.

30561. Indirect ?—Yes ; indirect counter-current principle. The gases are brought down in this apparatus to something like 20 degrees Centigrade, and, of course, there the total moisture, or practically the total moisture, is deposited and a great deal of the ammonia, in cases of wet coal being charged into the ovens, and that is the general rule in this country, because of the dirtiness of the coals being used for coking, the smalls. Anything up to 80 per cent. of the ammonia is deposited in these coolers, there is a good deal of the tar gets through the water-coolers. Then the last traces of the tar are taken out in a cold tar cleanser, either of the Pelouze type, or any of the well-known tar cleaners.

30562. Does the gas come into contact with the water at that stage ?—No, it does not touch water at all at the present moment. Then the gases, still containing a certain quantity of ammonia, say 20 to 30 per cent. of the total ammonia, are passed through scrubbers and there, for the first time, they meet water. The general rule is that the first scrubbers are fed with the condensings, that is to say, the condensings from the water-coolers and from the air-coolers which are passed into a settling tank where they cool, and the tar settles out from what we call the liquor.

30563. And that is a solution of ammonia at that stage ?—That is so ; something like 1 to 2 per cent. of ammonia. Then that liquor is fed to the top of the first two scrubbers and meets the gas, taking out a certain quantity of ammonia, but of course the last traces have to be taken out with fresh water, which is fed on a third scrubber.

30564. Is it not sometimes the case that dilute sulphuric acid is used for taking out the ammonia ?—I believe so ; I understand that is a process.

30565. That is the old process in short ?—Yes, exactly, the old process, in short.

30566. What is done with this ammonia liquor in the old process ; is it distilled with lime ?—It is taken to the sulphate house and it is passed down stills ; steam is passed against it and, at a certain point, lime is mixed into it.

30567. And the ammonia is distilled off and caught in sulphuric acid as sulphate of ammonia ?—As sulphate of ammonia.

30568. And the refuse is really what remains in the still ?—That is so.

30569. And the refuse is what is generally used either in quenching the coke or it is sprayed on some burning material, or it is evaporated ?—Well, for quenching coke I do know certainly of plants where it is strongly diluted and used for coke quenching, but to use it neat, as it is after settling the lime out or the insoluble lime salts out it is very difficult, especially if one has to market the coke afterwards.

30570. The colour is destroyed ?—The colour is destroyed ; it is very dirty.

30571. Whether the coke is really damaged or not is a different story, but the colour is destroyed ?—Yes ; and further as one uses now a great deal mechanical quenchers there is some difficulty in quenching at all.

30572. Then the other process is evaporation, but that of course is costly ?—Yes.

30573. And requires such a quantity of water ?—Yes.

30574. And the third plan is to spray on some burning material ?—Yes, a tip heap or something of that sort.

30575. Then the next question is, what is the difference between that system, which I think we now understand unless any member would wish to ask any question, and the process which is being now introduced, the Otto-Hilgenstock Coke Oven Process ?—Shall I describe it ?

30576. If you will kindly describe it ?—The idea now is not to cool the gases, as heretofore, before taking out the by-products, which consist of course of tar and ammonia. We take the gases now from the hydraulic main with practically all their tar contents. We pass them straight into the sulphate house.

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30577. The gases, I understand are at a high temperature ?—Yes,

30578. Considerably above 200 Centigrade ?—At the hydraulic main they are, but on the way to the sulphate house they may fall to something like 110, or lower still.

30579. Always above the boiling point of water anyhow ?—It is not absolutely necessary that they should be above the boiling point of water.

30580. But they do, I think, happen to be ?—Yes ; and there we subject them to a strong spray of tar, in fact the tar suctions the gases from the oven.

30581. Is it a sort of tar pump which the gases pass through ?—It is a nozzle. It is a special shape of a tar injector.

30582. A tar injector ?—A tar injector which creates a very fine spray of tar.

30583. It acts in the same fashion as a water injector would for carrying air ?—Exactly ; it collects the very fine tar particles which are in the gas, and deposits them in the tank or drum which is below.

30584. And the tar is pumped round and used again ?—Yes. And that which is made will over-flow into the tar tanks, and of course, the quantity of gas and the quantity of tar used are in distinct ratio, a distinct proportion to one another, and the whole secret of the tar spray is to take the tar quantitively out at a temperature above the dewpoint of the gases.

30585. The passing through this tar injector must cool the gases considerably ?—We have that entirely in our own hands. Yes, it certainly cools the gases, but our intention and our aim is to keep the gases from depositing any liquor.

30586. Any moisture ?—As long as we can keep above the dewpoint of the gas that is sufficient.

30587. You are safe. Then after passing through this tar extractor what becomes of the gases ?—Then they are in a fit state, a clean enough state, to enter the saturator. They are pumped by exhausters, straight through the saturator.

30588. That is to say it comes directly into contact with water ?—No, with sulphuric acid.

30589. Sulphuric acid ?—In the case of making sulphate of ammonia, we pass it through what we call a saturator, a lead-lined or a lead vessel containing sulphuric acid, with a dip-pipe, sealed in sulphuric acid, and the whole of the oven gases are subjected to cleansing with sulphuric acid.

30590. And then there is no waste ; no tar practically goes into the sulphate of ammonia ?—No ; a very very thin froth is skimmed off. By the way the saturator is worked there is a continuous overflow and it is continuously circulated so that just an occasional froth is taken off.

30591. And the solution is boiled down, I presume ?—No ; the salt is continuously ejected. We are working with a super-saturated solution of sulphate.

30592. Then you use pretty strong sulphuric acid to absorb the ammonia ?—Yes, something up to 150 Twaddel.

30593. So that really the ammonia sulphate crystallises out there and is used again to wash fresh gases ?—Quite so. The saturators being shaped in such a form that the salt falls down to the bottom and is mechanically ejected with steam.

30594. Would it be possible to apply this system to water, to saturate it pretty fully with ammonia, instead of using sulphuric acid to scrub the gases ; would it be possible to scrub them with water if a saturated solution of ammonia was wanted ? I believe in some cases there is a market, not for sulphate of ammonia in that dry state, but for a fairly strong solution of ammonia ?—In that case of course, the first point would be to cool them down.

30595. Yes ?—And they contain, generally speaking, where we deal with wet coals, a quantity of moisture which would relieve the gases of a very big quantity of ammonia straight away.

30596. And then you could afterwards scrub them with your sulphuric scrubber so as to take out the last traces ?—Yes.

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30597. There is absolutely no residue ; there is nothing to evaporate ?—There is nothing to evaporate ; the gases on leaving the saturator pass straight on to the ovens. Supposing we were working, the tar near the dewpoint of the gas, this with wet coal being somewhere about 75 to 80 degrees Centrigrade, the action of the ammonia in the saturator brings up the temperature slightly, so that the gases can be passed back straight to the ovens without fear of condensation.

30598. Do you get no refuse of any kind from the sulphate of ammonia plant ? Is it ejected in a white state, or a marketable state ?—Absolutely.

30599. Are there no impurities to accumulate in the mother liquor and make you finally reject it ?—Nothing at all.

30600. Never ?—Never.

30601. That is an ideal process ?—Of course, there is a difference between regenerative ovens and waste-heat ovens. As a rule in the waste-heat oven the gas from the whole of the charge is passed back to the oven and burned for heating the charge. Now, in the other case, in the regenerative oven, often a surplus of gas is required. The idea of a regenerative oven, of course, is to create as large a surplus of gas as possible, and this gas, if it is to be used for lighting purposes or for gas engines, at the present time has to be cooled down so that half the gas, generally one can say that 50 per cent. of the gas, of a good coal is saved. One gets 50 per cent. of the total gas as surplus from a regenerative coke oven. That quantity would have to be cooled down, but the liquor resulting from that comes out of the gas, which contains practically no ammonia whatever. It has gone through the saturator, and consequently the solubility of SH_2—sulphuretted hydrogen—and HCN are considerably lower than they are in ammonium salts, so that this liquor which is produced can be used for washery water or for quenching. I do not know about boilers ; I have not tried that yet.

30602. But for general purposes ?—For general purposes

30603. (*Colonel Harding.*) I merely want to ask, the claim that is made for your system, so far as the point that interests us is concerned, is this, is it not, that the effluent is reduced in volume and is in much purer condition ; is not that so ?—That is all that we can claim up to date. We have no plant as yet that is working absolutely without an effluent.

30604. So that you do get an effluent, but it is small in volume ?—That is so.

30605. And what is the character of it as to purity ?—Leading up to that question. I may mention that at the five plants in operation on the Continent, the waste liquor question, especially in Westphalia, is not so serious, or not considered so serious, as in this country, so there is very little advantage for them over there to avoid cooling their gases down after the ammonia and the tar have been extracted.

30606. You see the point that specially interests us, is in regard to the resultant liquid ?—Yes.

30607. What I want to know is, whether, by your process, we can reduce the volume of the residual liquor, and whether it will be in a condition more fit to be sent into the river than the present liquors ?

30608. (*Chairman.*) I do not see where the liquor can be if you do it thoroughly. You first scrub to get out the tar, and then afterwards you pass it through the sulphuric acid to get out the sulphate of ammonia ; where is the liquor ?—Well, the moisture in the coal comes into the gas, or a certain percentage comes into the gas

30609. And deposits in the pipes ?—No. Under the old process of course the gases were cooled down to ordinary temperature, and a large quantity of liquor is deposited as condensings, from the gases. Now, what we aim at is to prevent any condensing of this steam in the gas.

30610. It comes ultimately into the sulphuric acid scrubber ?—Yes.

30611. That evaporates away the water as it is formed ?—It never condenses.

30612. Or it does not condense enough ; precisely ?—It is above its dewpoint, and therefore there would be no deposit of water.

30613. You lead the gases direct to the ovens ?—Yes.

30614. It passes through the ovens ; there again there is no deposit, except on the road ?—Except on the road. We have not any plant where on the return journey, at the present time, the gases are not depositing some quantity of liquor, but that is reduced. The lowest we can show yet is approximately 4½ gallons per ton of coal.

30615. (*Colonel Harding.*) Now what condition is it in ?—It is difficult to say.

30616. Is it a polluting liquor, or is it a fairly clear liquor, and is it free from objectionable chemical matter ?—Well, if I compare it with the old waste liquor it has no lime in it at all.

30617. (*Chairman.*) It has no solids in it, you will say ?—It has no solids in it. It comes down at such a temperature, say at 70 degrees, that SH_2 and HCN are practically insoluble, so that only the slightest trace, I do not know that even we have found traces in this.

30618. It is very nearly distilled matter, probably with a slight smell ?—Yes, it has been in contact with gas, and of course, there is a certain, there must be a certain trace of gas.

30619. It is a question of smell more than anything else ?—Yes.

30620. (*Colonel Harding.*) You say you are able to obtain this result of having a smaller volume and a better quality of effluent, at the same time that you are able to bring about a greater production of the by-products. It is an economical advantage to use this plant ?—Certainly. Apart from the capital outlay, you can see the condensing plant is radically simplified, and the stills are completely abolished ; the steam for the stills is not necessary, the lime for the stills is not necessary.

30621. You get the by-products at less cost ?—Certainly.

30622. And you get them also in greater quantity ?—In this way, that we claim to minimise at any rate, the loss of ammonia. In the old system this waste liquor contained anything up to ·01 per cent. of ammonia and, as we make no waste liquor now, there is no loss.

30623. Now where are you likely to have your first apparatus at work in England ?—In Scotland at Messrs. James Nimmo & Co.'s Auchengeich Colliery.

30624. Will that be an important plant ?—Yes, a plant of thirty ovens. The by-product plant laid out to deal with gases from sixty ovens.

30625. Can you tell us when the plant is likely to be in operation ?—Any time I think from next May to June.

30626. Would you be good enough to inform us when it is in operation ?—Certainly.

30627. (*Chairman.*) Thank you. We are very much obliged to you for coming ; it has been most interesting evidence.

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GREAVES, PERCY C., MINING ENGINEER; AND HOLIDAY, ROSLYN, MINING ENGINEER AND GENERAL MANAGER OF THE ACKTON HALL COLLIERIES OF FEATHERSTON, YORKSHIRE, ON BEHALF OF THE MINING ASSOCIATION OF GREAT BRITAIN (*Analysis of their Evidence*):

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HALLIWELL, EDWARD, F.I.C., CHIEF INSPECTOR TO THE RIBBLE WATERSHED JOINT COMMITTEE (*Analysis of his Evidence*):
Statement respecting trades in the Ribble Watershed in which large volumes of water are used; Processes in manufacture; character and treatment of effluents:
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(2) Calico bleaching, printing and dyeing.
(3) Brewing, pp. 29–31.
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Large amount of water used in connection with calico bleaching, 27880–3.

Satisfactory process for dealing with brewery waste, 27884.

Precipitation and filtration the methods adopted, admixture of sewage unsatisfactory, 27885–9.

At present manufacturers deal with waste liquids by removing suspended and precipitated matter, 27890.

At a large expense, 27891.

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But this has much improved the state of the rivers, 27893–4.

A standard for effluents would not greatly improve them, 27895–7.

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Difficulties explained, 27909–11.

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Power of entry to any part of works at any time required for proper officers, 27940–7.

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Amendment of Rivers Pollution Acts desirable in regard to power of entry, 27951.

Power of entry obtained from a court of law in special cases only useless, 27952.

Powers of entry to reach point of discharge or suspected point of discharge required, 27953–5.

Manhole for inspecting effluents passing into sewers provided in most towns, 27956–7.

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HANSON, JOHN H., AND HAIGH, JOHN, REPRESENTING A FIRM OF ENGINEERS, TO THE WEST RIDING OF YORKSHIRE MILLOWNERS AND OCCUPIERS' ASSOCIATION; SYKES, ALFRED, J.P., PRESIDENT OF THE ASSOCIATION; MILLS, CHARLES, SOLICITOR TO THE ASSOCIATION; AND WHITAKER, THORP, OF THE BRADFORD DYERS' ASSOCIATION (*Analysis of their Evidence*) :

Statement by Mr. Hanson respecting the Association (woollen and worsted industries): correspondence with West Riding of Yorkshire Rivers Board; Huddersfield and Heckmondwike Local Acts and the reception of sewage into sewers of Local Authorities; questions submitted by the Sewage Commission; establishment of Central Authority; standards: trade effluents: and the establishment of Rivers Boards, pp. 105–7.

Statement by Mr. Sykes respecting certain provisions of the Huddersfield and Heckmondwike Local Acts; desirability of establishment of a Central Authority and standards; Rivers Boards and their duties; and discharge of trade effluents into sewers, pp. 107–9.

Memorandum of Mr. Mills respecting the Association; anomalies of the law as affecting trade effluents; suggestions for the amendment of the law so as to require Local Authorities to receive trade effluents into their sewers; standards; procedure in regard to trade effluents; Mr. Atter's evidence respecting new sources of pollution, the abuse of purification works, short tenancies, liquid refuse dealt with by contractors, samples, discharge by joint outlet, procedure, and proceedings against firms; assessment of annual value; and summary of suggestions on several points, pp. 109–112.

The 241 members of the Association represent and include all the branches of and the more important firms in the woollen and worsted trades, 29244–9.

Uncertainty of legislation in regard to responsibilities of manufacturers and Local Authorities has been a difficulty and led to friction, 29250–1.

Advisable that Local Authorities should deal with trade effluents, 29252.

The Association has helped to bring about arrangements on the point which will form a basis for similar arrangements in other places, 29253–5.

The arrangements are on the basis that the Local Authorities shall receive trade effluents subject to certain conditions as to preliminary treatment or payment in lieu thereof, 29256.

Desirable that suspended matter and grease should be eliminated from effluents before running them into sewers, 29257–8.

In large towns many manufacturers will practically be obliged by want of room at their works to make payments to Local Authorities in lieu of preliminary treatment, 29259–60.

Amount of payment agreed in Halifax and Huddersfield, 29261.

In some cases manufacturers will have to run purified effluents into rivers, 29262–3.

Large volumes of effluent may possibly in some cases prevent Local Authorities receiving them in sewers, 29264.

No such case yet in the West Riding of Yorkshire, 29265.

Local Authorities in the West Riding more willing than formerly to receive trade effluents, 29266.

Advantage which would have resulted from the establishment of a Central Authority in the past, 29267.

Lack of knowledge on the part of Rivers Board and of manufacturers in regard to treatment of trade effluents has caused trouble, 29268.

Experience gained by manufacturer and Rivers Board has resulted in improved conditions, 29269–71.

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Objects of the Association have been to ascertain, first, the legal position, and next, practical means of dealing with trade effluents: methods adopted, 29275–6 and 29285.

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Advice given by Association to manufacturers, improvement in purification plant since 1898, 29282–4.

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The standard must be a financially practicable one, 29291–3.

Cost of purification too high in some cases, case referred to, 29294–8.

Treatment of effluents in Lancashire, 29299–301.

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In practice there are more difficulties in dealing with effluents in works than in laboratories, 29303.

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A fixed standard desirable, 29315, 29318–22 and 29325.

The standard might be raised subsequently, 29316, 29325 and 29329.

After a term of seven or ten years, 29323–5 and 29330–1.

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The Inquiry before raising a standard should be held by the Central Authority, 29333.

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Manufacturer must make provision for purification at new works, 29350.

Or will be liable to prosecution for pollution of stream, 29350–2.

Procedure suggested by the Association, 29353 and 29357–8.

Reference to that under existing Acts, 29354.

Purification tanks not always provided in the past, 29356.

Any notice that purification works will be required should be given by the Local Authority and not by Rivers Board, 29360–1 and 29364–6.

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Accessibility of effluents for that purpose, 29369.

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In cases of the abuse of purification works employer should be liable to penalties, but should have power to bring actual offender into court: Acts referred to containing similar provisons, 29377–8.

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No difficulty in connection with arbitration: course in Huddersfield referred to, 29384–6.

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HART, H. W., F.C.S., AND — POTTER, REPRESENTING THE WALL PAPER MANUFACTURERS, LTD. (*Analysis of their Evidence*):

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KING, A. J., M.P., B.SC., DIRECTOR OF THE BLEACHERS' ASSOCIATION, BOLLINGTON, MACCLESFIELD. (*Analysis of his Evidence*):

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LAW, ALTERATIONS IN, WITH RESPECT TO TRADE EFFLUENTS:

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LAW, ALTERATIONS IN, WITH RESPECT TO TRADE EFFLUENTS—*continued.*

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LAW, ALTERATIONS IN, WITH RESPECT TO TRADE EFFLUENTS—*continued.*

Statement by Leach (pp. 90–2) and *Marshall* (pp. 92–3) *on questions put by the Sewage Commission as to purification of trade effluents, standards, for, and alteration of the law in regard to.*

Expression "manufacturers" in Rivers Pollution Acts not regarded as including all industries, such as "wool-washing," *Leach* and *Marshall*, 29097–9.

No alterations of the law required except to require manufacturers to adopt reasonable means of purification of effluents (*Mr. Robert Clay's Statement*), pp. 102–3.

Suggestions as to alterations of the law in regard to reception of trade effluents into rivers, alteration of procedure, etc., *see Mr. Mills Memorandum*, pp. 109–112.

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No alteration in the law respecting rivers pollution by paper trade required beyond setting up suitable standards enforced if necessary by an outside authority, *Wathen*, 29882–3.

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Rivers Pollution Acts should be altered to make Local Authorities use their powers under the Acts, and to give County Councils more power, *Williams*, 28172–81.

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Rivers Board or Sanitary Authority should, as in Germany, have the power of preventing the establishment of a source of pollution subject to appeal to a Central Authority, *Maclean-Wilson*, 28408–10.

LEACH, WALTER, F.C.S., AND MARSHALL, HAROLD, SOLICITOR, REPRESENTING WOOLCOMBERS, LTD. (*Analysis of their Evidence*) :

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Statement respecting the disposal of trade effluents when not mixed with sewage: methods adopted and quality of effluent, etc., in different trades: dyeing, calico printing, bleaching and finishing, print trade, woollen trade, paper making trade, waste bleach works, fellmongers and tanning works, breweries, and unclassified works, pp. 75 and 76.

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Where no system of filtration purification is incomplete, 28546.

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TOD, JAMES N., MANAGING DIRECTOR OF MESSRS KELSALL AND KEMP, LTD., AND TOYNE, FRANCIS D., M.A., F.C.S., CHEMIST OF THAT FIRM (*Analysis of their Evidence*):
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Brewery—*continued.*

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  - Ammonia recovery works, *J. T. Wilson*, 27540.
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  - These effluents should go into the sewers, difficult to treat by themselves, *ib.*, 28292.
  - Sewers not available in all cases, *ib.*, 28293.
  - Method of treatment where sewers are not available, *ib.*, 28294.
  - Does not pay to withdraw matter from fellmongers effluents, *ib.*, 28302–3.
  - These effluents pollute streams in the West Riding of Yorkshire, *ib.*, 28307.
  - Fellmonger's effluents at present going into streams less likely to be run into sewers than those from tanneries: difficult case in Sheffield referred to where Corporation refuse to admit a fellmonger's effluent to the sewers, *ib.*, 28308–9.
  - The lime in suspension and solution in fellmonger's effluents is the difficulty, *ib.*, 28309–11.
  - The lime in suspension could be easily eliminated, *ib.*, 28312.
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  - Effluent discharged from fellmonger's works in the West Riding of Yorkshire comparatively small, *ib.*, 28318–22.
  - Capacity of settling tanks required by Leeds Corporation for the effluent before its admission into sewers: discussion respecting, *ib.*, 28322–8.
  - No such requirement in other places, *ib.*, 28329–30.
  - *See Stowell and Scudder's Statement*, pp. 75 and 76 and 28545–64 and 28682–92.
  - Cost of purification of fellmongers' and tanners' effluents not prohibitive, *Stowell* and *Scudder*, 28550–64.
  - Effluents from tanneries pass into sewers, *ib.*, 28690.
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  - Particulars as to paper making, etc., *ib.*, 27687–781.
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  - Cannot afford to provide expensive plant for purification of effluents owing to circumstances referred to, *ib.*, 27826–30 and 27845–7.
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  - Majority of paper mills are situated in boroughs or large urban districts, *ib.*, 27831–40.
  - Analytical tables of effluents, *ib.*, pp. 46, 47, and 48.
  - Statistics of paper mills in the West Riding of Yorkshire, and discharge of their effluents into sewers or streams, *Maclean Wilson*, 2 28333–5.
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  - If there is solid matter in the effluent putrefaction takes places, but not otherwise, *ib.*, 28354.
  - *See Stowell and Scudder's notes*, pp. 74, 75, and 76, and 28565–6, 28622, 28599, 28600, 28627–37, 28670–2 and *Annandale, Tod* and *Law*, 29718–36.
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  - Which places home manufacturers at a financial disadvantage, wood pulp principally used abroad, less difficulty with effluent from, *ib.*, 29813.
  - Messrs. Pirie's paper mill waste and effluent, *Wathen*, 29819–54.
  - Paper mill effluent need not be purified beyond prevention of nuisance in river, *ib.*, 29854.
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  - Recovery of soda from paper mill pays but not recovery of lime, *ib.*, 29867–8 and 29961–2.
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  - *See Statement handed in by Mr. Hart and Mr. Potter respecting questions put by the Sewage Commission as to purification, standards, and alteration of the law in regard to paper trade effluents*, etc., pp. 153 and 154.
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  - Methods adopted in dealing with waste liquids at the Almond Mill, *ib.*, 30186–8.
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  - Were there larger quantities it could be made into hydraulic cement, *ib.*, 30205.
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  - Admitted by paper makers that all practicable purification of their effluents is necessary, *ib.*, 30380–2 and 30477.
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    - Matter in lead mining effluent can be prevented from passing into rivers by inexpensive settling tanks, *ib.*, 27620.
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    - Swilling effluent from tin plate works turned into tidal waters, *ib.*, 28020.
    - Effluent from tin plate works sometimes kills fish, *ib.*, 28036.
    - Should be run into rivers in small quantities at a time, *ib.*, 28037.
    - No tanks used, but swilling fluid is passed over limestone chippings, *ib.*, 28038.
    - Effect of swilling liquid on lime, *ib.*, 28042–4.
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- Woollen—*continued.*
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Woollen—*continued.*

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Woollen—*continued.*

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Woollen—*continued.*

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Nor cattle to any great extent, *ib.*, 27627.

They depreciate property, *ib.*, 27628.

Experiments carried out in Lanarkshire for removing the discolouration, *ib.*, 27629.

Difficulty in proving what is a noxious polluting liquid in prosecutions at law for prevention of discolouration, *ib.*, 27630 and 27638.

Methods of reducing colouring matter in effluents referred to, *ib.*, 27636–7.

No other methods tried, *ib.*, 27650–1.

Standard for trade effluents in Lanarkshire otherwise than in relation to suspended matter and discolouration not suggested, *ib.*, 27640–2.

A universal standard for Lanarkshire is required in regard to suspended matter in effluents for each industry, but different standards are required in regard to discolouration and poisonous matter, *ib.*, 27643–6 and 27652, *also* 27657–60.

TRADE EFFLUENTS—*continued.*

General—*continued.*

The standard for suspended matter would be determined by that required for coal-dross washings or for lead washings, *ib.*, 27643 and 27647.

There would be a difficulty in securing a very high standard for matter in suspension in effluents, *J. T. Wilson*, 27654.

What standard would be sufficient, *ib.*, 27655.

There should be a universal standard of pollution for the Clyde in regard to matters in suspension in effluents for each particular industry, *ib.*, 27657–60.

Effluents from trades in the Ribble Watershed. *See* Statement handed in by the Chief Inspector to the Ribble Joint Committee, *Halliwell*, pp. 29–34.

Effluents of works in the watershed of the Ribble all treated before discharge, *Halliwell*, 27683–4.

Quality of effluent varying at times, *ib.*, 27685.

Manufacturers getting better results in their effluents than formerly, *ib.*, 27766.

Effect on streams unsatisfactory, *ib.*, 27767 and 27769.

Discussion as to possibility of improvement, *ib.*, 27782–8

Improvement might probably be effected by passing worst effluents into sewers, *ib.*, 27789 and 27795.

Some of the worst might be discharged into sewage works without affecting treatment of sewage, *ib.*, 27791.

Discharge of the worst effluents into sewers would not affect riparian rights, but all trade effluents could not be passed into sewers, *ib.*, 27804.

Local Authroities cannot be compelled to receive trade effluents into sewers, case of Peebles *v.* Oswaldtwistle Urban District Council referred to, *ib.*, 27805–11.

Manufacturers and local authorities awaiting legislation determining whether the latter shall be compelled to receive trade effluents, *ib.*, 27814–21.

Capacity of sewers to take trade liquids depends on which of the liquids are to be taken, *ib.*, 27841.

Considerable relief could be given if the worst liquids were taken, *ib.*, 27842.

Dealing with the remaining effluent, *ib.*, 27843–4.

Complaints received in respect of discolourisation of rivers, *ib.*, 27879.

A standard for effluents would not greatly improve them, *ib.*, 27895–7.

Variations in trade effluents, *ib.*, 27898.

Sulphuretted hydrogen a trouble, *ib.*, 27899–27901.

Standards for trade effluents would be extremely useful, *ib.*, 27906–7.

Difficulties in adopting standards, *ib.*, 27908.

Difficulties explained, *ib.*, 27909–11.

Theoretically no difficulty as regards suspended matter but impracticable for financial reasons under existing law, *ib.*, 27912–30.

"The practicable and available means" differ in nearly every case, *ib.*. 27925.

The onus of proof that it is financially impossible to reach a standard should be thrown on the manufacturer, *ib.*, 27927–35.

Manufacturers should have facilities for acquiring land for purposes of purifying effluents, *ib.*, 27937–9.

A manhole accessible to officials of local authorities should be provided in all cases where trade effluents pass into sewers, *ib.*, 27965.

Analytical tables of effluents, *ib.*, pp. 46–52.

Expectation of legislation prevents manufacturers from improving efflvents, *Williams*, 28093–5.

TRADE EFFLUENTS—*continued.*

General—*continued.*

Statement handed in showing that the provisions of Section 14 of the Local Government Act, 1888, are not conducive to the enforcement of the Rivers Pollution Acts in ordinary cases of pollution, question of cost involved, *ib.*, 28170–1.

Recovery of matter from various trade effluents of advantage to the manufacturers, instances referred to, *Maclean Wilson*, 28397–8.

Improvement in rivers brought about by removal of suspended matter in effluents and purification of sewage, *ib.*, 28487 and 28492–3.

The fixing of standards is not practicable in the West Riding of Yorkshire, the "reasonable and practicable" limit clause is preferable *ib.*, 28496.

Statement respecting the disposal of trade effluents when not mixed with sewage, methods adopted and quality of effluents, etc., in different trades, dyeing, calico printing, bleaching and finishing, print trade, woollen trade, paper making trade, waste bleach works, fellmongers and tannery works, breweries and unclassified works, *Stowell and Scudder*, pp 75 and 76.

Law requires no amendment as regards the disposal of trade effluents into streams on the Mersey and Irwell Watershed, but similar requirements to those enacted therein should be exacted elsewhere Mersey and Irwell Joint Committee Act referred to, *ib.*, p. 76, *see also* 28665–8.

Method of determining what is a satisfactory effluent, *ib.*, 28525–9.

Removal of suspended matter in effluents first required, requirements and practice of the Mersey and Irwell Joint Committee, *ib.*, 28530–44.

Putrefaction does not occur in print works refuse but in refuse from organic substances, and from fellmongers, tanners, and certain bleach works, *ib.*, 28535.

Production of harmless trade effluents simply a question of expense, *ib.*, 28540–4.

Present standard of purification required by the Mersey and Irwell Joint Committee, *ib.*, 28555–60.

A higher standard hoped for, *ib.*, 28561–2.

Elimination of suspended matter in trade effluents sufficient to prevent injury to the river, *ib.*, 28576–7.

Practice of the Mersey and Irwell Joint Committee in relation to purity of trade effluents, fixed standard not desired, *ib.*, 28595–8.

Standard for discolouration adopted, *ib.*, 28601–2.

Motor works discharging refuse into rivers in district of Mersey and Irwell Joint Committee, *ib.*, 28652.

Passes into the sewers, *ib.*, 28653.

Lime in trade effluents makes the water harder, *ib.*, 28693.

Standards, discussion as to: one fixed standard for effluent for each particular trade advised, *Tod* and *Toyne*, 28781–5.

Each trade should be dealt with separately, *King*, 28889.

Establishment of Central Authority to deal with the question desirable, *ib.*, 28891–2.

Standards should be for the effluents, not for the rivers receiving them, *ib.*, 28905: *Hanson, Sykes, Mills* and *Whitaker*, 29512.

Statements by Leach (pp. 90–2), *and Marshall* (pp. 92–93) *on the questions put by the Sewage Commission as to purification of trade effluents, standards for, and alteration in the law in regard to.*

Standard for trade effluents should be based on effluent proceeding from treatment of the worst class of material treated, *Leach* and *Marshall*, 28914–5.

TRADE EFFLUENTS—*continued.*

General—*continued.*

To base standard for effluent on character of the stream into which it flows might place one manufacturer at a disadvantage compared with another, discussion on the point, *ib.*, 28919–23.

Discussion as to standards and best practicable treatment of effluents, *ib.*, 29085–9.

Not necessary for notice to be given to persons setting up new works that purification of effluents will be required, *Leach* and *Marshall*, 29124.

A common trade standard for effluents would be advantageous, *ib.*, 29130.

Local Authorities should be compelled to receive trade effluents into their sewers, *ib.*, 29145–6 and 29149.

Local Authorities in certain districts receive them, *ib.*, 29147.

In some districts the sewers are not able to receive them, *ib.*, 29148.

Any question in special cases as to the practicability of a Local Authority receiving effluent should be determined by the Central Authority, *ib.*, 29150–2.

Arrangements with Halifax Corporation for taking effluents into sewers, *ib.*, 29153–6.

Taking of samples of effluents, *ib.*, 29164–7.

Reference to provisions in Halifax Corporation Act, 1905, for enabling, *ib.*, 29168–9.

No objection to taking of effluents, *ib.*, 29170–2.

Difficulty in making standards for, *Clay* and *Marshall*, 29183–7.

Standard should vary according to the conditions of the stream from which water used by the manufacturer is taken and into which effluent is discharged, *ib.*, 29188–90.

Trade competition requires that an equally pure effluent should be required from all manufacturers in the same trade, *ib.*, 29190–2.

Except in any case where manufacturers might be unable to get land for treatment of his effluent, *ib.*, 29192*–5.

Certain colours used in dyeing difficult to remove from effluent, *ib.*, 29196–7.

A uniform standard should if possible be required *ib.*, 29227–36.

But it is necessary that the character of the stream and the position of the works on it be taken into account, *ib.*, 29237–8.

Difficulties in connection with the reception in sewers of trade effluents would place some manufacturers at a disadvantage, *ib.*, 29238–40.

Purification of and reception in sewers. *See Statements by Mr. Hanson*, pp. 105–107; *Mr. Sykes*, pp. 107–109; and *Memorandum of Mr. Mills*, pp. 109–112.

Advisable that Local Authorities should deal with trade effluents, *Hanson, Sykes, Mills* and *Whitaker*, 29252.

Arrangements made by West Riding of Yorkshire Millowners' and Occupiers' Association on the basis that the Local Authorities shall receive trade effluents subject to certain conditions as to preliminary treatment or payment in lieu thereof, *ib.*, 29256.

In large towns many manufacturers will practically be obliged by want of room at their works to make payments to Local Authorities in lieu of preliminary treatment, *ib.*, 29259–60.

In some cases manufacturers will have to run purified effluents into rivers instead of into sewers, *ib.*, 29262–3.

Large volumes of effluents may possibly in some cases prevent Local Authorities receiving them in sewers, *ib*, 29264.

Local Authorities in the West Riding of Yorkshire more willing than formerly to receive, *ib.*, 29266.

TRADE EFFLUENTS—*continued.*

General—*continued.*

Lack of knowledge on the part of Rivers Board and manufacturers in the West Riding in regard to treatment of has caused trouble, *ib.*, 29268.

Experience gained by manufacturers and Rivers Board has resulted in improved conditions, *ib.*, 29269–71.

Doubtful whether treatment of effluents improves streams for traders' purposes : acidity results, *ib.*, 29302.

In practice there are more difficulties in dealing with effluents in works than in laboratories, *ib.*, 29303.

Reference to case where trader has got rid of acidity in, *ib.*, 29303–5.

Uniform trade standard desirable, *ib.*, 29312 and 29394.

A standard that can be reasonably attained should be fixed at first and a higher standard subsequently, *ib.*, 29313, 29327–8 and 29334.

A fixed standard desirable, *ib.*, 29315, 29318–22 and 29325.

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Powers should be given to supervising authority to take samples of effluents, *ib.*, 29368 and 29376.

Accessibility of effluents for that purpose, *ib.*, 29369–70.

Samples may be taken when effluent is flowing from machine, *ib.*, 29372.

Samples should be taken from the final point of discharge when all the trade refuse from the particular works is mixed into one effluent, *ib.*, 29373–5.

The more difficult problems in treatment of effluents from the works of the Association not numerous, *ib.*, 29372.

Difficulties amongst traders in reaching standard, should be one that all can at once reach, *ib.*, 29395.

One trade standard desirable irrespective of character of river, *ib.*, 29418.

Legislation with regard to passing of effluents into sewers and standards of pollution desired, *ib.*, 29419–22.

Certain difficulties in connection with pollution of rivers by, *ib.*, 29423–4.

Mr. Whitaker's paper with reference to Bradford Dyers' Association and the effluents from their works, p. 122.

Replies of the Association to questions as to purification of effluents, standards and alteration of the law respecting, pp. 122 and 123.

Effluents from works belonging to that Association, *ib.*, 29438–41.

Each class of work or trade should have its standard, *ib.*, 29477–8 and 29482.

Treatment of in certain districts, *ib.*, 29484–90.

Particulars as to results, *ib.*, 29491–3.

Effluents should be purified till fit for animals to drink and for fish life if financially practicable, *Roberts*, 29523–5.

Question of standard a difficult one, *ib.*, 29653–8.

A standard would probably not be applicable to a whole trade, *ib.*, 29663–4.

See Statement handed in by Mr. Hart and Mr. Potter respecting questions put by the Sewage Commission as to purification of trade effluents, standards for, and alteration of the law in regard to, pp. 153 and 154.

Local Authorities should take sewage and effluent from any factory which is rated for sanitary or sewerage purposes. *Evans, Edwards, Green, Jepson* and *Taylor*, 30550*a*.

WATHEN, H. A. D., DIRECTOR OF MESSRS. ALEXANDER PIRIE AND SONS, LTD., PAPER MANUFACTURERS (*Analysis of his Evidence*) :

Chief sources of polluting waste from Messrs. Pirie's works, 29819–20.

Do not necessarily reach the river, 29821.

WATHEN, H. A. D.—*continued.*

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Others treated, 29824.

Details, 29825.

Process of recovery of 70 to 75 per cent. of soda from waste described, 29825–7.

A remunerative process, 29828.

Soda used again, 29829.

Part from which soda is not recovered passes into effluent, 29830–8.

Only one effluent from works, 29831 and 29841.

Tank used to cause a regular flow, 29839–40.

No further treatment of effluent, 29842–3.

Effluent is turbid, 29844–5.

Particulars as to volume etc., of effluent, 29846–9.

Water supply from river, 29850.

The effluent causes only a small increase of suspended solids in the river, 29851.

Volume of effluent small in comparison with river receiving it, 29852–3.

Effluent need not be purified beyond prevention of nuisance in river, 29854.

Varying standards required for paper trade, conditions which should be taken into account, 29855–64 and 29963–9.

Standard must be a provisional one, 29862.

Condition of stream, nature of trade effluent and nature of treated effluent are the matters which should affect standard, 29863–4.

Paper mill effluents vary widely, 29865.

Have much improved in late years owing to improvement in processes, 29865–6.

Recovery of soda from effluent pays but not recovery of lime, 29867–8 and 29961–2.

Difficult to say whether a simple standard limiting suspended matter in, and requiring effluent to be neutral within certain limits, would be practicable, 29869.

Further purification of present effluent would probably not be financially practicable, 29870–6.

If insisted on might in some cases cause mills to be closed, 29877.

Purification of effluents in foreign countries, 29878–81.

No alteration of the law respecting rivers pollution required beyond setting up suitable standards, enforced if necessary by an outside authority, 29882–3.

Whether a Rivers Board for watershed should be the authority would depend on its constitution, 29884.

Should not be a Local Authority representing mixed interests, 29886–8.

Details as to method of disposal of refuse, 29889–97.

Use of alumina in purification, 29898–901.

Difficult and expensive in some cases, 29903–5.

Disposal of lime, expense connected with, 29906–7.

Disposal of refuse from bleaching materials, 29908–9

No trouble with coloured paper effluent, 29910–1.

Use of pulp, 29912.

No putrefaction of fibrous matters, 29913–4.

Effluent from mill slightly alkaline, 29915–6.

Cost of purification apart from recovery of soda, 29917–20.

Expert inquiry into state of River Don resulted satisfactorily for Messrs. Pirie, 29921–7.

Conditions at Messrs. Pirie's works, 29928–38.

Salmon in the river not affected by works so far, 29939.

No other works which would foul the river likely to be started, too difficult to struggle against foreign competition now, 29940.

River Don not used for drinking purposes, 29941–3.

Sewage flows into river below Messrs. Pirie's works, 29944.

The Don a swift river, 29945.

Other manufactories on the Don, 29946–8.

Result of expert inquiry into the river in regard to the other manufactories, 29949–59.

Recovery of soda from waste does not pay for the elimination of other substances, 29962.

Cement has been made from soda lime sludge from purification works, but not a financial success, 29970.

Farmers will not use the waste lime, 29971–2.

WHITAKER, THORP (*see under*, Hanson, John H. &c.).

WILLIAMS DR., MEDICAL OFFICER OF HEALTH TO THE GLAMORGAN COUNTY COUNCIL; AND **LEWIS, COLONEL**, CHAIRMAN OF THE SANITARY COMMITTEE OF THE GLAMORGAN COUNTY COUNCIL (*Analysis of their Evidence*):

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Very few settling tanks for coal-washing provided, 27978–80.
Difficulty in getting owners to provide them, 27981–2.
Coal-washing effluent is not pollution but discolouration, 27982.
Quality of effluent where settling tanks have been provided, 27983–5.
Pollution from tin plate works lessening, 27987.
Method adopted, 27988.
It pays, 27989.
Use of sulphate of iron recovered, 27990.
Further particulars as to method adopted, 27991–4 and 28007–12.
Glamorgan rivers not used for drinking purposes after sewage has entered, 27995.
Sewage, small coal, and tin-plate works the sources of pollution in Glamorganshire, 27996.
Canals in the county greatly polluted, 28000.
The expression "streams" in Rivers Pollution Acts should be defined to include canals, 28001.
Deposit of ochre by mine-water, 28002.
Sanitary inspector has not sufficient power to deal with collieries, 28004–6.
Limestone in the county, 28013.
Method of using limestone, 28014–5.
Tinplate manufacturers willing to purify liquids other than swilling fluid, 28016–9.
More swilling done in recent years, 28018.
The swilling effluent is turned into tidal waters, 28020.
Causes an accumulation on the shore, 28021.
Fish may be effected, oyster beds at Oystermouth are not, 28022–4.
900 tons sulphuric acid used weekly, 28025–6.
Waste pickle not always converted into copperas, 28027.
Not valuable, 28028–9.
Must be worked on the spot and has to be pumped up, 28030.
Manufacturers should be required to convert their waste pickle into copperas, 28031.
It would be to their advantage, 28032.
No authority to visit tinplate works, but manufacturers allow it, 28033–4.
Whether swilling fluid should be purified should depend on circumstances, 28035.
Effluent from tinplate works sometimes kills fish, 28036.
Should be run into rivers in small quantities at a time, 28037.
No tanks used, but swilling fluid is passed over limestone chippings, 28038.
Doubtful whether tanks should be provided, 28039.
No fish in rivers now, 28039–41.
Effect of swilling liquid on lime, 28042–4
Sulphate of lime does not harm rivers much, 28045–6.
Large number of people employed in coal mining in South Wales, 28046.
Numbers employed in, and in tinplate works, 28047.
Few collieries have settling tanks but the number is increasing, 28048.
Operations for saving small coal not largely adopted in Glamorganshire, 28049–57.
Only three bye-products works in the County, 28058–9.
Likely to increase in number, 28060.
Method of getting ammonia from waste liquor, 28061.
Polluting matters remaining in residue, 28062.
No cyanide compounds in residue, 28063.
Waste liquor has not been analysed, 28064.
Can enter works by permission, 28065.
Effluent filtered through sand and lime in one case, 28066.
Method of disposal in other cases, 28067–8.

WILLIAMS, DR., AND **LEWIS, COLONEL**—*continued*.

Not aware whether cyanide compounds are ever discharged, 28069.
Processes have been thoroughly investigated, 28070.
No facilities for treatment of waste liquors with sewage, 28071–2.
Not desirable that they should be so treated, 28074–5 and 28078–9.
Treatment of ordinary sewage in the neighbourhood, 28076.
Satisfactory in result, 28077.
Tanneries and fellmongers' works in the County few in number and small in size, 28080–2.
Brewing in Glamorganshire, 28083.
Waste in two cases in the Rhondda passes into sewers, 28084.
Causes no trouble for reasons given, 28085–7.
Chemists at bye-product works would be the best judges as to remedy for waste liquors from these works, 28088.
Condition of rivers improving as regards sewage and tin plate works pollution, but not as regards colliery effluents, 28089.
Periodical inspection of works doing good, 28090.
Expectation of legislation prevents manufacturers from improving effluents, 28093–5.
Much small coal is in effluent discharged into rivers in a certain case, 28098.
No analysis or samples taken of that effluent, 28099-28100.
Much deposit before floods, 28101–2.
Blackness of river banks, 28103–4.
No advantage in going to court, 28105–6.
Probable amount of deposit in a certain sample, 28108–9.
Great discolouration of rivers from coal washing, but only destructive of fish, 28111–3 and 28119.
All trout killed in the River Taff, 28114.
Only trout and salmon affected, not coarse fish, 28115–6.
No growth in the river, 28117.
Fish food, effect of deposit, 28118.
Standard for sulphate of iron can be easily attained, 28121–3.
Standard mentioned has been regarded as satisfactory, 28124.
Higher standard could be attained, 28125.
Doubtful if the standard would be high enough for fish life, 28126.
State of effluents reaching the standard, 28127–8.
Cost of recovering small coal from colliery effluents would be recouped by the value of it, 28129–32 and 28138.
Initial cost of plant probably prevents colliery owners from carrying it out, 28133.
All colliery effluents in Glamorganshire undergo some treatment, 28134–5.
But a large amount of coal is still in the effluent, 28136–7.
Coal-washing water largely used over and over again in Yorkshire, 28141.
To a certain extent also in Glamorganshire, 28142.
In some cases the result is that there is no effluent, 28145–6.
Difficult to get colliery owners to do it, 28146.
No trouble now from pollution by gas liquors and ammoniacal waters in Glamorganshire, 28148–9.
Copperas extracted from ammoniacal liquors, 28150–3.
Acidity of swilling water, 28155.
Kills fish, 28156.
In Glamorganshire swilling water is generally discharged on Saturdays, 28158.
Intermediate storage tanks for regulating flow would be of advantage but no powers under the Rivers Pollution Acts to enforce the provision of, 28159.
Would be inexpensive, 28160.
Cannot generally get manufacturers to provide them, 28161–4.
No power to make manufacturers provide them except by taking legal proceedings, 28165–7
Statement handed in showing that the provisions of Sec. 14 of the Local Government Act, 1888, are not conducive to the enforcement of the Rivers Pollution Acts in ordinary cases of pollution, question of cost involved, 28170–1.

WILLIAMS, DR., AND LEWIS, COLONEL—*continued.*

- Suggestion that the law should be altered to provide that complaints of pollution should be sent to the County Council to take action, the costs in any litigation to be borne by the District Council of the locality, with power of appeal to the Local Government Board, 28170.
- Local authorities refuse to use their powers under the Rivers Pollution Acts, suggesting that the Acts should be altered to make them take action, and to give County Councils more power, 28172–81.
- Members of the authorities are themselves sometimes concerned in the river pollutions, 28174.
- Water supply in Glamorganshire is in a bad state both as regards quality and quantity, 28181–2.
- Actions at law by the County Council have failed for want of power, 28183.
- No Rivers Board in Glamorganshire, 28184.
- And only short rivers, 28185.
- Advantageous to group them into a drainage area, 28186.
- Additional powers required to prevent tipping of refuse into rivers by Local Authorities, colliery owners, etc., 28186–91.
- Prosecutions under Sec. II. Rivers Pollution Prevention Act, 1876 failed, District Councils should be made responsible for rivers, at present they do not take necessary action, 28192.
- Difficulties in instituting prosecutions, County Council fail to prosecute, 28193–201.
- Particular cases referred to, 28202–3.
- A large number of colliery and tin mine owners on the County Council, 28204.
- Area for which a Rivers Board might be constituted, 28206.
- Drinking of effluent of tin plate works by cows said to bring on abortion, 28209–11.

WILSON, H. MACLEAN, CHIEF INSPECTOR OF THE WEST RIDING OF YORKSHIRE RIVERS BOARD (*Analysis of his Evidence*) :

- Rivers Aire and Calder and their tributaries are the Yorkshire rivers mainly polluted by trade effluents, 27280–1.
- River Don grossly polluted by ochre water, 27281.
- Number of sources of pollution in Yorkshire very great, 27282.
- 2005 is the net number of premises in his district in which trade refuse is produced, 27283.
- 941 of these discharge into streams, the remainder into sewers, thus lessening pollution of streams, 27286–90.
- Of the 941 premises there are purification works in about 651, not all satisfactory, 27291–4.
- Of the remaining 290 premises in many cases the sanitary authorities have resolved to deal with the trade effluents and connect the premises with sewers, 27295.
- West Riding of Yorkshire Rivers Board prefers that trade effluents should be run into sewers but does not bring pressure to bear on the point, 27296–8.
- Willingness of Local Authorities to receive trade refuse into sewers increasing, 27299–300.
- In Halifax all trade refuse is received into sewers, and charge made for, in addition to rates paid, 27300–2.
- *Statistics of different trade premises in the West Riding of Yorkshire in which trade refuse is produced, p. 10.*
- Relative importance of different trades in regard to excess of pollution of streams, 27304 and 27307.
- Separate works for bleaching, 27305.
- Few places for bleaching wool, 27306.
- Effluent from washing wool the most polluting, but small in quantity, 27308.
- Difficult to treat, 27309.
- Grease withdrawn from the wool, 27310.
- By "seak-tanks" or "sap-pits," 27311–5.
- Effluent polluting after withdrawal of grease, 27315.
- Difficult to purify, 27316.
- Treatment of wool effluent, and constituents of, 27317–20.
- Purification of wool effluent by filtration, 27323–5, and 27328–30.

WILSON, H. MACLEAN—*continued.*

- Effluent from Bradford Sewage Works, 27325–7.
- Fermentability of effluent from seak tanks, 27331–3.
- Filtration generally ineffective, 27334.
- Filtration possible, but very expensive, 27335–7.
- Experiments unsatisfactory, 27338–41.
- Effluent from piece scouring, less objectionable and weaker than that from seak-tanks, 27342–5 and 27353–4.
- Successful method of treatment of effluent from piece and yarn scouring adopted at Hopton Mills, Mirfield, 27346–51.
- Can be practically dealt with, 27362.
- Difficulty of purifying wool scouring effluent by filtration, 27352, 27355–6.
- Should be the subject of study, 27363.
- Experiments in treatment of trade effluents regarded as outside the work of the West Riding of Yorkshire Rivers Board, 27357–9.
- Sewage Commission is expected to take this matter up, 27357, 27359 and 27360.
- Certain Companies or Associations might be approached in connection with experimental works, 27361–71.
- Pollution by coal-washing, 27372–5.
- Methods adopted for dealing with effluent, 27376–80, 27386 and 27387
- Character of resulting effluent, 27381–2.
- Pollution greatly reduced, 27383–5 and 27388.
- Due to action of West Riding of Yorkshire Rivers Board, 27384.
- No difficulty in collieries avoiding pollution, 27388.
- Pollution by gas liquor a serious matter, 27389.
- Sources of production of gas liquor, 27390–1.
- Effluents from manufacture of gas discharged into the sewers, 27392–4.
- But trouble arises in sewage works, 27394–5.
- Names of districts where trouble has arisen, 27397 and 27399.
- Can be avoided by preliminary treatment, 27398.
- Methods adopted on recommendation of Dr. Fowler of Manchester, 27399–408.
- At Bradford Sewage works at Frizinghall, 27459–60.
- Advantage of diluting gas liquor with sewage, 27409–10.
- Should be investigated by the Sewage Commission, 27411.
- Certain constitutents are withdrawn from the gas liquor before it is an effluent, 27412–6.
- Characteristics of the effluent, 27417–8.
- Objectionable, 27419–20.
- Result unsatisfactory after withdrawal of certain constituents, 27422.
- Mr. Theodore Koch's paper respecting gas-liquor effluent, 27424.
- Increase of production of gas liquor by coke ovens in collieries, 27426–9.
- Attempts to purify gas liquor, 27430–1.
- Evaporation of gas liquor, 27631–3.
- Method adopted for, 27434.
- Evaporation adopted at Hemsworth Fitzwilliam Colliery, 27450.
- Costliness of evaporation, 27436–8.
- Evaporation taints the air, 27439–42.
- No complaint received in respect of evaporating plant, 27443.
- Different methods proposed for dealing with gas liquor, 27444.
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Rivers Board or Sanitary Authority should, as in Germany, have the power of preventing the establishment of a source of pollution subject to appeal to a Central Authority, the power would be rarely exercised, 28408–10.
At present works with grossly polluting effluents can be established and at least a year and, possibly, many years must pass before effective action can be taken to stop the pollution, 28411–3.
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Some years will elapse before purification works of the boroughs are complete, Bradford, Leeds, Halifax and Huddersfield are carrying out works, 28469.

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The fixing of standards is not practicable in the West Riding of Yorkshire, the "reasonable and practicable" limit clause is preferable, 28496.

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Areas of County of Lanark and City of Glasgow for Rivers Pollution Acts purposes, 27516–8.
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Silicious material in the effluent, 27530.
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Effluent containing non-putrefactive matter in suspension objectionable, but not made the subject of law proceedings except where resulting from roasting of ore, 27534.
Galena is extracted from lead mine effluent, 27535–7.
Effluent from coal-washing, easy to reduce amount of, 27538.
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Disposal of the effluent in different works, 27543 and 27544.
Phenols are the polluting substances in the effluent and not cyanides, 27545 and 27546.
Inimical to bacterial life, and may, if discharged into sewers, disorganise the septic tank and filters of sewage plant of a small town, 27547, 27549 and 27551.
No method yet devised that will render it innocuous to germ life, 27548.
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Colouring matter in effluent the chief trouble in connection with paper making, 27555.
Greater part removed by chemical precipitation, 27556.
Better method desirable, 27557.
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Lime used in making brown papers does not reach the sewers, 27559.
Methods of eliminating and disposing of lime from the effluent, 27560–1.

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- Effluent from calico printing deeply coloured, 27562.
- Turkey red and other colours cannot be recovered, as in paper making, by calico printers, 27563–4.
- May be precipitated by sulphate of alumina, 27565–6.
- Whether effluent from calico printing would silt up sewers is a point for investigation, 27566.
- The effluent is very flocculent, 27567.
- The effluent can be treated in the Glasgow sewage works, 27568.
- Glasgow Corporation make conditions with regard to admission of trade effluents, 27569.
- A Central Board should determine whether a company should be required to provide settling ponds for effluent, 27570–1.
- Satisfactory results can be obtained with the usual sewage treatment as regards dyeing, bleaching and finishing, 27572.
- No trouble anticipated from chemical works 27573.
- Distillery refuse can be disposed of, 27574 and 27578.
- It is a question whether differences in mine water may not affect any standard for the effluent from coal dross washing, 27579.
- Would be under control if the law comprehended mine drainage, 27580.
- Particular works which should be visited and examined, 27581–5.
- Noxious liquids may be run into disused mines where no natural drainage outlet exists, 27586.
- Particular printing and dyeing, bleaching and chemical works which should be visited, 27587.
- Pollution of the Clyde above Glasgow considerably reduced, Glasgow sewage the principal cause of the pollution of the river, 27588.
- Adjustable standards should be laid down for particular districts and particular works, 27589–90.
- No difficulties have arisen by reason of regulations varying in different places, 27592–4.
- County Council have practically all the powers of a Rivers Board, 27595, 27601 and 27611–12.
- Explanation of the position and powers of different authorities in Scottish counties under existing law, 27602.
- The Cart River, 27603–6.
- Several Scottish County Councils taking up the question of pollution of rivers, 27607.
- Power of Secretary for Scotland to compel Local Authorities to enforce Rivers Pollution Acts if complaint is made, 27608–10 and 27670.
- Where water sheds extend into different counties a Joint Board would be advisable, 27613.
- Difficulties attending the enforcement of a standard for an effluent, 27614.
- County Council have no power to prevent the deposition of certain solid matters from effluents in rivers, 27615–7.
- The law should fix a standard for the effluent, 27617–9.
- What constitutes a noxious polluting liquid should be decided after investigation, 27617.
- Matter in lead mining effluent can be prevented from passing into rivers by inexpensive settling tanks, 27620.
- General character of residual effluent from gas liquors from different plants the same, 27621.
- All objectionable, 27622.
- This class of effluent is the most important in Lanarkshire to deal with, 27623.
- Purification of should be a subject for the study of the Sewage Commission, 27624.
- Coloured effluents the next most important in Lanarkshire, 27625.

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- Does not think they affect fish, 27626.
- Nor cattle to any great extent, 27627.
- They depreciate property, 27628.
- Experiments carried out in Lanarkshire for removing the discolouration, 27629.
- Difficulty in proving what is a noxious polluting liquid in prosecutions at law for prevention of discolouration, 27630 and 27638.
- The law should be amended so as to determine what is a noxious polluting liquid, 27631.
- Another word for "noxious" should be substituted in the enactments to meet the case of depreciation of property, 27632–3.
- Reference of certain questions to a Central Board probably useful, 27633.
- No laboratory experiments for determining what are noxious liquids have been carried out by the Lanarkshire County Council, 27634.
- Methods of reducing colouring matter in effluents referred to, 27636–7.
- No other methods tried, 27650–1.
- Riparian owners in a stronger position than Local Authorities in dealing with pollution of rivers, 27639.
- Great change would be effected in Lanarkshire if there were no litigation at common law in regard to pollution, 27639.
- Does not suggest standards for trade effluents in Lanarkshire otherwise than in relation to suspended matter and discolouration, 27640.
- A universal standard for Lanarkshire is required in regard to suspended matter in effluents for each industry, but different standards are required in regard to discolouration and poisonous matter, 27643–6, 27652 and 27657–60.
- The standard for suspended matter would be determined by that required for coal-dross washings or for lead washings, 27643 and 27647.
- Sufficient room in works in Lanarkshire for provision of settling tanks, etc., for purifying effluents from coal and lead mine washings, 27648–9.
- Different standards of pollution for different reaches of the Clyde unnecessary, 27653.
- Difficulty in securing a very high standard in regard to matter in suspension in effluents, 27654.
- Difficulty in securing a very high standard for matter in suspension in effluents, 27654.
- What standard would be sufficient, 27655.
- No woollen works in Lanarkshire, 27656.
- Calico and bleach works: there should be a universal standard of pollution for the Clyde for each particular industry in regard to matters in suspension in effluents 27657–60.
- Manufacturers co-operate with Lanarkshire County Council, 27662.
- Reference to trade representatives who might oppose his evidence, 27663.
- No trouble with distillery refuse, 27665.
- If a longer term were allowed for repayment of loans for sewage purification works in Scotland there would be more readiness to provide them, 27666.
- Suggesting that the Sewage Commission might consider whether the period for the repayment of such loans should not be extended, 27669.
- Loans for sewerage and sewage purification works: periods for: position and powers of authorities in relation to, different in England and Scotland: discussion respecting, 27666–73.

WOOLLEN TRADE EFFLUENTS, *see under* Trade Effluents.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

GENERAL REPORT BY THE OFFICERS OF THE COMMISSION UPON Mr. W. J. DIBDIN'S SLATE BED PROCESS. 1911.

In view of the fact that a number of Local Authorities had adopted Mr. Dibdin's slate beds as a preliminary process in the disposal of their sewage, the Commission decided, at the request of the Local Government Board, to make some inquiry into the merits of this process.

On December 18th, 1908, Mr. Dibdin submitted a list of places at which slate beds had been installed. Three installations, namely, those at Devizes, East Dereham and Machynlleth, were selected from this list as being the most suitable for observation.

The working of the slate beds at each of these three places was kept under observation for rather more than a year.

Occasional visits of inspection were made throughout this period, records of daily fillings were kept, and, at the beginning and the end of the observations, the capacities of typical beds were measured.

Average samples of sewage and of slate bed effluent were also taken, both at the beginning and at the end of the observations.

In their Fifth Report, p. 67, the Commission made the following statement with regard to slate beds:—

> "As the result of our inspection of the beds at Devizes, we came to the tentative conclusion that primary beds containing large slabs of slate must be regarded more as preliminary settling or septic tanks than as contact beds."

As regards the effluent which results from the treatment of sewage in slate beds, this conclusion has been borne out by the observations which have since been made.

The effluent from a slate bed is, for practical purposes, indistinguishable from a tank effluent. It contains about the same amount of suspended matter, and requires subsequent treatment similar to that which would be necessary for a tank effluent from the same sewage.

The calculated "strengths"[*] of the various liquors at the three places, taken from the whole of the analyses, are:—

	Crude Sewage.	Settled Sewage.	Slate Bed Effluent.
Devizes - - -	175	—	130
East Dereham - -	118	—	95
Machynlleth - -	59	52	46

The slate bed effluent at Devizes, therefore, is a very strong liquor, that from East Dereham a strong one, and that from Machynlleth a somewhat weak one.

The following table shews the percentage reduction of suspended matter effected by the treatment of sewage in slate beds at the three places. Below it is given another table showing the settlement obtained in ordinary settling and septic tanks.

Slate Beds.

Suspended Solids. Parts per 100,000.

Place.	Crude Sewage.	Settled Sewage.	Effluent from Slate Beds.	Percentage Reduction due to treatment in Slate Beds.
Devizes, 10 sets of average samples	42·8	—	14·2	66·6
Dereham, 11 sets of average samples - - -	17·9	—	9·4	47·5
Machynlleth, 10 sets of average samples - -	11·4	8·4	6·1	27·4[†]

The following figures are taken from the Fifth Report, pp. 122–125:—

Continuous Flow Settlement.[*]

Suspended Solids. Parts per 100,000.

Place.	Crude Sewage.	Rate of Flow in Tanks (expressed as time taken to fill Tanks in dry weather).	Settled Sewage.	Percentage reduction in suspended Matter.
		Hours.		
Clifton - -	49·1	5·3	24·2	51
Halton - -	17·7	15·5	10·7	40
Leeds - -	58·1	4	12·8	78
Leeds - -	58·1	8	11·7	80
Sheffield -	50·2	8	10·7	79
Oldham - -	51·2	12	15·8	69

Septic Tank Treatment.

Suspended Solids. Parts per 100,000.

Place.	Crude Sewage.	Rate of Flow in Tanks (expressed as time taken to fill Tanks in dry weather).	Septic Tank Liquor.	Percentage reduction in suspended Matter.
		Hours.		
Accrington -	43·3	42	19·4	55
Andover -	16·5	19·3	11·1	33
Birmingham -	48·4	10·1	19·5	60
Exeter (St. Leonards)	26·1	17·8	8·4	68
Exeter (Main Works) -	37·2	11·5	12·5	66
Guildford -	42·1	36·7	15·9	62
Hartley Wintney -	20·1	31·7	15·1	25
Huddersfield	40·0	24	13·1	67
Ilford - - (experimental)	27·2	24	10·8	60
Knowle -	19·4	15·2	8·4	57
Leeds - -	63·0 59·8	24	25·7 17·8	59 70
Manchester -	35·0	15	10·8	69
Rochdale -	36·7	30	5·3	86
Slaithwaite -	10·7	13·6	7·1	34
York - -	21·2	26	5·3	75

It is clear, therefore, that the practical rules which apply to the subsequent treatment of settled sewage and septic tank liquor apply also to the treatment of the effluent from slate beds.

The observations at Devizes and Dereham show that single contact of the slate bed effluents from strong and average sewages cannot be relied upon to produce a satisfactory effluent. The single contact beds yielded at both these places opalescent and strong smelling liquids.

At Machynlleth, a good non-putrescible effluent was being obtained by the treatment of a weaker slate bed effluent on percolating filters, at a rate of about 40 gallons per cube yard per 24 hours in dry weather.

Loss of Capacity in Slate Beds.

The capacity of a new slate bed is about 85 to 90 per cent. of the capacity of the empty tank.

From the measurements of the capacity of the slate beds at the three places under observation, it is clear that the greater part of this capacity can be maintained permanently, if the sludge which collects in the beds is habitually allowed to come away after the beds have been run off.

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[*] *Cf.* Fifth Report of the Commission, App. IV., p. 1, *et seq.*

[†] Calculated on the settled sewage.

[*] We are unable to give any comparative data with regard to quiescent settlement of sewage.

At Devizes, after having received for five years an average of 0·9 filling per day of sewage containing about 43 parts of suspended matter per 100,000, the slate beds retained 75 per cent. of their original empty tank capacity. During the period of observation, *i.e.*, in the fourth and fifth years of their life, the capacities of the two beds gauged remained practically constant. Here the valves of the beds had been opened every morning to let out the accumulated sludge.

It has been calculated that the average rate of loss of capacity in the Devizes slate beds during the first five years of their life was only about 100 gallons per million gallons of sewage treated.

At Machynlleth, after having received for two years an average of about 3 fillings per day of settled sewage containing from 8 to 9 parts of suspended matter per 100,000, the beds retained 79 per cent. of their original empty tank capacity. Here the valves of the beds had been left wide open after each filling.

The average rate of loss of capacity at Machynlleth has been estimated at about 48 gallons per million gallons of sewage treated. As already stated, however, the sewage is partially settled before being sent into the slate beds.

At Dereham, where, in order to prevent clogging of the contact beds, the sludge has been purposely retained in the slate beds, there was a serious loss of capacity.

After receiving 1·1 fillings per day of sewage, containing about 18 parts of suspended matter per 100,000, for rather less than 18 months, these beds retained only about 44 cent. of their original empty tank capacity.

In this case the average rate of loss of capacity was 1,126 gallons per million gallons of sewage treated.

Despite the attempt to retain the sludge in the slate beds at Dereham, the contact beds receiving the slate bed effluent also suffered serious loss of capacity.

It has been suggested that slate beds may be flushed out when they become clogged. We know of no place at which this has been done and cannot, therefore, express any opinion as to its practicability.

In our opinion, however, even allowing for the possibility of washing the beds, it is desirable that provision should be made for the partial discharge and disposal of sludge at *frequent* intervals.

The neglect of some such provision would tend to induce clogging in the filter beds used subsequently, while, if the slate bed effluent were dealt with on land, nuisance would probably arise in the feed channels.

For the same reasons it would in all cases be advisable to provide some form of tank or settling chamber—not necessarily of large capacity—for the deposition of suspended solids carried forward in the slate bed effluent.

SLUDGE DIGESTION.

It may be taken broadly that between 40 and 60 per cent. of the suspended matter of an average sewage is mineral.

Of the remainder, a considerable proportion consists of cellulose and other matter which is known to decompose under biological action only very slowly at ordinary temperatures.

It is clear, therefore, that the maximum digestion of sewage suspended matter which could be anticipated from any biological process would be considerably less than 50 per cent., even under the most favourable circumstances.

Owing to the difficulty of making accurate measurements of sludge at the works under observation, it is impossible to give any precise estimate of the digestion of sludge which takes place in slate beds.

From the data which have been obtained with regard to Devizes, however, the digestion, or, more correctly, the diminution in solids, which takes place in the slate beds there would appear to be very small. The actual figure obtained was only 1 per cent. of the total suspended solids.

SLUDGE PRODUCTION AND DISPOSAL.

Although it is possible to work slate beds in such a manner as to postpone for a considerable time the necessity for dealing with any sludge, it appears to us that the practice is not likely to prove economical.

It will be seen that, at Dereham, where this method was adopted, not only the slate beds themselves, but also the contact beds used in conjunction with them became seriously clogged.

At Devizes, where the beds are drained out once a day, there were produced about 6·2 tons of sludge per day, or 2,260 tons per annum, containing approximately 95 per cent. of water.

This represents about 1·55 tons of dry solid matter, or 15·5 tons of sludge containing 90 per cent. of water, per million gallons of sewage. It must further be noted that, at Devizes, storm sewage is passed through detritus tanks before being sent into the slate beds, and also that special slate beds are set aside for the treatment of some of the sewage which arrives in storm times.

Comparing this sludge production with that of septic tanks, we may note that at Manchester (Davyhulme), where the whole of the sewage is passed through detritus tanks, and where special sedimentation tanks are used for storm sewage, the production of sludge from the septic tanks was 12·3 tons per million gallons, containing on the average 87·5 per cent. of water, or 15·37 tons containing 90 per cent. of water. These figures relate to the year ending March, 1910.

At Machynlleth, the weak sewage is partially settled before it is sent into the slate beds, and only slight further deposition takes place in the latter.

In this case the production of slate bed sludge per million gallons was about 1·7 tons, containing 90 per cent. of water.

Provided that the sewage is not allowed to remain too long in the slate beds, the slate bed sludge differs from ordinary sewage or septic tank sludge in that it possesses only a slight odour, resembling that of sea-weed, and that it is full of minute forms of animal life. When examined under the microscope, the number of actively motile vibrios is a striking feature. Numbers of small worms are also to be found in the sludge as it lies on the slates.

Mr. Dunkerly, of the Lister Institute, has been kind enough to examine two samples of the Devizes sludge for the Commission, and a copy of his report is appended.

A paper by Mr. Dibdin on the slate bed sludges at Devizes and High Wycombe is to be found in *The Analyst* for 1907, p. 108. This paper embodies certain investigations on the subject by Dr. G. J. Fowler and others, which go to show that the organic matter of the sludge (apart from the worms and other small animals present) is in active process of inoffensive decomposition, as it lies on the slates.

If the sludge after removal is allowed to remain wet, it putrefies and gives rise to an offensive smell, but there is little doubt that when drained *quickly* in a shallow layer, it can be dealt with almost without nuisance. It is to be clearly understood, however, that if this satisfactory result is to be attained, a sufficient number of thoroughly good draining beds or lagoons must be provided for the reception of the sludge; when drained, it can be dealt with at leisure.

A considerable volume of very foul liquor must necessarily drain away from these sludge lagoons. This should be collected and sent back for re-treatment.

SMELL FROM SLATE BEDS.

The smell which arises from sewage works where slate beds are installed may be taken as similar in kind and intensity to that which occurs where crude sewage is treated in contact beds. Once the sewage is in either type of bed, there is practically no smell, but during the filling of the beds solid sewage matter collects on the surface of the material, whether slate or clinker, etc., and necessarily gives rise to local nuisance. These deposited solids can, however, be swept into the slate bed as it fills up.

As regards the slate bed effluent itself, it may be said that this is more liable to give rise to nuisance, when distributed, than precipitation liquor, but less liable than septic tank liquor.

Compared with other preliminary processes of sewage purification, slate beds will probably be found to be expensive as regards capital outlay; but, on account of the *sludge* being comparatively odourless, we think that the claims of the process deserve consideration in cases where the reduction of smell at a sewage installation is of primary importance.

We consider it undesirable to treat *settled* sewage in slate beds, since this defeats one of the main objects of the process. At Machynlleth, in our opinion, the slate beds might have been dispensed with, without deleterious effect upon the general results of the sewage treatment there.

CONSTRUCTION.

As in the case of quiescent flow tanks, the use of slate beds involves considerable loss of head.

In order to prevent septic conditions arising in slate beds, through too prolonged a stay of the liquor in them, it would be necessary to divide the slate bed area into a number of units—probably not less than six or eight. This would mean increased capital expenditure.

The drawing off of slate bed liquor must be done as gently and equably as possible, so as to avoid unnecessary disturbance of the sludge. In some cases it might be of distinct advantage to provide separate valves for drawing off the sludge from the slate bed floors, in addition to the outlets employed for the slate bed liquor proper.

GEORGE McGOWAN.
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October, 1911.

REPORT BY MR. DUNKERLY ON DEVIZES SLATE BED SLUDGE.

Two samples of material were examined, one of which (*A*) was liquid sludge run out from the slate beds, and the other (*B*) was the deposit found on the slates.

Sample A was swarming with a colourless biflagellate, *Polytoma uvella*, which is often found in decaying infusions. The organisms were evidently in quite congenial surroundings, as dividing forms were numerous, division taking place within the original cell membrane.

Although *Polytoma* is described as being saprophytic in its method of nutrition, stained specimens in preparations made from the sample seemed to contain *Spirilla*, although it cannot be said from present observations that *Polytoma* actually ingests the bacteria.

One or two polymastigote forms were seen, resembling *Trichomastix*, with three short and one long flagella. These were probably derived from an animal in which they are parasites. Very few Nematodes were present in this sample, but their eggs were occasionally met with.

Large very active *Spirilla* forms of bacteria were numerous.

After 24 hours the Flagellates and Spirilla were still more numerous; and, after the sample had been left covered for some days, Nematode worms (*see* below, sample B) were numerous, having hatched out apparently from the eggs previously seen, but by this time a common Infusorian, *Cyclidium glaucum*, was also present, probably indicating contamination.

Sample B.—Small mature forms of Anguillulid Nematode worms were very numerous; these I have not identified at present, but similar forms are frequently found in decaying organic material in the soil. One or two living Diatoms were found, also *Euglena viridis*, a Flagellate constantly found in the drainings from stable manure, as well as in ditches, etc. *Polytoma uvella* was present, but not in large numbers; small saprophytic Flagellates, *Bodo sp.*, were numerous.

In stained preparations made from sample *B*, *Spirochaetes* appeared to be numerous, chiefly small forms resembling *Sp. dentium*; but one or two elongate forms resembling *Sp. pallida* of syphilis were seen, though these are rather uncertain. After some days *Cyclidium glaucum* appeared in this, as in sample A. In both samples *A* and *B*, sulphur bacteria were present, but not particularly plentiful.

Lister Institute
Chelsea, S.W.
July, 1911.

J. S. DUNKERLY.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

REPORT TO THE COMMISSION ON THE WORKING OF MR. DIBDIN'S SLATE BED PROCESS, BY MR. A. C. CARTER, F.I.C. AND MR. A. F. GIRVAN, B.Sc. JANUARY, 1911.

INTRODUCTORY NOTE.

The object of the observations was to ascertain :—

(1) The degree of settlement effected by the slate beds.

(2) The amount of sludge produced.

(3) The extent to which sludge was digested in the beds.

(4) The loss of capacity of the slate beds.

(5) The effect which the effluent from the slate beds had on the contact beds or percolating filters on which it was subsequently treated.

(6) Whether there was nuisance from smell.

The observations were carried out at Devizes, East Dereham, and Machynlleth, these places having been selected by the Commission, after consultation with Mr. Dibdin, as being the most suitable.

Place.	Population.	Date of starting installation.	Date at which observations were begun.	Nature of sewage.	Average dry weather flow per 24 hours.
Devizes - - -	6,500	September, 1905	April, 1909	Very strong, containing refuse from a brewery, a bacon factory and a large dairy.	200,000
Dereham - - -	5,500	March, 1909	July, 1909	Of medium strength, with refuse from a brewery.	50,000
Machynlleth - -	2,000	September, 1908	September, 1909	Wholly domestic, except for a very small ginger beer factory, and rather weak.	41,000

At each place records of the number of fillings of the slate beds were kept.

At Devizes and Machynlleth the sludge which had settled at the bottom of the beds was collected, sampled and measured.

At Dereham all solid matter stays either in the slate beds or the contact beds.

Method of Treatment.

At Devizes the crude unscreened sewage is run direct on to the slate beds, except in time of storm, when it is settled in the first instance; at Dereham it passes first through a very small grit chamber; at Machynlleth it is settled.

Subsequent Treatment of the Effluent from the Slate Beds.

At Devizes the subsequent purification is effected by very fine contact beds, at Dereham by fine contact beds or percolating filters, and at Machynlleth by percolating filters.

Description of the Slate Beds.

The beds are constructed of superimposed layers of slates (each slate about 1 foot to 3 feet, by about ¼ inch thick), separated by small pieces of block slate, 2 to 2½ inches in thickness.

The slate is built up to an average height of 3 feet, and the beds are usually filled with sewage liquor to a depth just short of this.

Besides some shorter visits, others extending over several days were paid to :—

Devizes in September, 1909, and September, 1910.
Dereham in July, 1909, and September, 1910.
Machynlleth in September, 1909, and September, 1910.

During these visits average samples of corresponding crude sewage[*] and slate bed effluent were taken over periods of seven days on the first, and three days on the second visit, in the following manner :—

Three samples of the liquid as going on to each of the beds, and three corresponding samples of the effluent were taken every day.

The first sample of sewage was taken when each bed was about one-sixth full, the second when it was half full, and the third when it was about five-sixths full.

At the end of the day the separate samples of sewage thus obtained were mixed, in equal quantities, and the mixture was taken for analysis, and the same was done in the case of the slate bed effluent.

DEVIZES.

The Devizes sewage works are situated about one mile from the centre of the town. The sewerage of the town is on the partially separate system. The average daily dry weather flow of sewage is about 200,000 gallons. As will be seen later, the sewage is a very strong one, a reason for this being that it contains the waste liquors from a large brewery, a bacon factory and a large dairy.

The installation consists of two detritus tanks, eight slate beds, and ten contact beds. The dimensions of the tanks and beds are as follows :—

1 detritus tank, 46′ 6″ × 22′ 6″ × 3′ 6″ deep.
1 detritus tank, 46′ 6″ × 30′ × 3′ 6″ deep.
1 slate bed, 44′ × 70′ × 4′ deep[†] }
1 slate bed, 46′ × 70′ × 4′ deep } for dealing with the dry weather flow.
4 slate beds, each 45′ × 68′ × 4′ deep }
2 slate beds, each 80′ × 68′ × 4′ deep, for dealing with the storm water.

The ten contact beds are all of similar dimensions, viz., 45′ × 68′. They are filled to a depth of 4 feet with coke breeze, which is graded as follows :—

Top, 3′ 3″ — ⅛″ to ½″ diameter.
Bottom, 9″ — 2″ to 3″ diameter.

Method of Working the Slate Beds.

The whole flow of crude unscreened sewage is sent into each slate bed in turn. During dry weather each bed takes about 3 hours to fill in the day-time and from 6 to 8 hours at night. If the sewage is very strong, it is allowed to rest in the bed for a further period of 2 hours, and the liquor is then run off to be treated in the contact beds. If it is weak, with little matter in suspension, it is run off almost at once.

When the outlet valve is first opened, in emptying the beds, a considerable amount of black suspended matter comes away with the liquid. Thus, an average of 10 samples, taken every minute for the first ten minutes after a bed was opened, gave 30·4 parts per 100,000 of solids in suspension.

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[*] At Machynlleth average samples of the settled sewage were also taken.

[†] These figures refer to the dimensions of the empty tanks.

This suspended matter causes considerable trouble by clogging the surface of the very fine material of the contact beds. Larger pieces of suspended matter (paper, etc.) were also to be observed on the surface of these beds.

Each of the smaller slate beds (which were the only ones in use during the periods of sample taking) usually requires about 3½ hours to empty. If the liquor is run off at a faster rate, a considerable amount of suspended matter comes away with it all the time.

From a constructional point of view this would be a matter of considerable importance in a large installation. It would probably be found advisable to use a larger number of small beds in preference to a smaller number of large ones.

When a bed becomes nearly empty, a close watch has to be kept on the issuing liquid, or the sludge which has collected on the bottom of the bed will run out in quantity. At this stage the valve is nearly shut, which allows the bed to drain without the sludge escaping.

In times of storm the sewage is passed through one of the detritus tanks before running on to the slate beds.

Sewage and Slate Bed Effluent.

The following figures of analysis were obtained for the average sets of samples* drawn in April, 1909 and September, 1910 :—

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* These samples of slate bed effluent examined did not contain any of the suspended matter which comes away when the valve of a bed is first opened.

DEVIZES.

Table A.—*Parts per* 100,000.

	Samples drawn from 2nd to 9th April, 1909.				Samples drawn from 6th to 9th September, 1910.				
	No. of Analyses.	Crude unscreened Sewage.	Effluent from Slate Beds.	Percentage reduction on the crude Sewage.	No. of Analyses.	Crude unscreened Sewage.	Effluent from Slate Beds.	Percentage reduction on the crude Sewage.	Percentage reduction on the crude Sewage, calculated on the combined samples.
Ammoniacal nitrogen - - -	5	**6·30** (5·68—7·43)	**7·03** (6·34—7·49)	—	3	**5·42** (5·00—6·00)	**5·74** (5·44—6·04)	—	—
Albuminoid nitrogen - - -	5	**1·57** (1·17—2·00)	**1·16** (0·92—1·38)	26·1	3	**1·60** (1·39—1·72)	**1·15** (0·91—1·28)	28·1	27·1
Total organic nitrogen - - -	5	**3·54** (3·07—3·87)	**2·49** (1·67—3·32)	29·7	3	**3·36** (3·15—3·50)	**2·76** (2·04—3·26)	17·9	25·4
Total nitrogen - - - -	7	**10·99** (8·88—18·8)	**9·19** (7·10—10·27)	16·3	3	**8·78** (8·43—9·15)	**8·55** (7·88—9·01)	2·6	12·9
Oxygen absorbed from $\frac{N}{8}$ permanganate—at once	4	**3·33** (2·72—4·06)	**4·00** (2·12—5·93)	—	3	**3·55** (3·29—3·56)	**4·03** (2·75—5·02)	—	—
Oxygen absorbed from $\frac{N}{8}$ permanganate—after 4 hours	7	**21·51** (13·39—41·60)	**13·30** (8·36—19·96)	38·1	3	**16·02** (12·72—17·94)	**15·03** (11·11—19·13)	6·2	30·4
Solids in suspension - - -	7	**44·6** (34·9—60·2)	**14·9** (12·2—20·3)	66·1	3	**38·6** (36·8—40·8)	**12·7** (11·8—13·6)	67·1	66·6
Volatile matter in these suspended solids	7	**34·7** (28·2—47·4)	**12·5** (10·6—16·7)	63·9	3	**29·1** (28·0—31·0)	**10·7** (10·4—10·9)	63·2	63·6
Solids by centrifuge (Vols.) - -	7	**266·7** (203·0—374·2)	**84·9** (53·2—102·6)	68·1	3	**343·3** (262·8—404·5)	**81·2** (59·0—108·0)	76·3	71·1
Chlorine - - - - - -	7	**20·10** (13·42—46·66)	**18·14** (13·16—29·70)	—	3	**24·51** (19·50—32·00)	**24·05** (17·10—32·62)	—	—

The figures in brackets are the maxima and minima.

Settlement effected by Slate Beds.

The figures in the foregoing table show that the slate beds effected a reduction of about 66 per cent. in the suspended matter of the crude sewage.

Accumulation of Sludge.

In the course of 24 hours, about 1 to 2 inches of black sludge collect at the bottom of a slate bed. Every morning the outlet valves of those beds which have been draining overnight are opened, and the sludge is run on to a triangular lagoon (40 × 40 × 30 yards) to dry. This sludge possesses a strong seaweed, but not offensive, odour. The slate bed sludge is also, on occasion, run on to an osier bed, of about 2 acres in extent, when the lagoon is unable to cope with it.

During wet weather, when the detritus tanks are in use, the sludge from these is also allowed to run over the osier bed.

It was found impossible to estimate the amount of this latter sludge (which was considerable). In places the dry deposit measured 6 inches to 1 foot in depth.

Measurements of the volume of the liquid sludge which issued from the slate beds every morning were made over a period of 12 weeks, by allowing the sludge to drain into one of the effluent channels and subsequently taking its average depth.

Eleven average measurements were made and samples were taken every eighth day, on different days of the week (*i.e.*, eleven samples in all).

The channel measured 327 feet by 1 foot 11 inches, and the average depth of the sludge was 4·28 inches, which is equivalent to a daily average of 1,396 gallons.

The average percentage of *dry* solid matter in the sludge was 4·33 (dried at 110°C.).

From these data it has been calculated that about 100 tons of dry solid matter issue from the six small slate beds in this way per annum.

This corresponds to 510,000 gallons of liquid sludge, or about 200 tons of air-dried sludge.

These figures are most probably an under-estimate, as the weather was very wet during the period over which measurements were taken, and the detritus tanks were therefore in frequent use. These tanks thus received a considerable quantity of the suspended solids which would have otherwise passed into the slate beds.

On one occasion a bed was opened up near a division wall, for the purpose of examining the deposit on the slates at various depths. The deposit was thinnest at the top, being scarcely ¼ inch thick there, but increased in thickness towards the bottom, where it averaged quite an inch.

It was brown in colour on the surface, but black and very gelatinous underneath. It was full of small red worms.

Digestion of Sludge in the Slate Beds.

From the figures for suspended solids given in Table A, it has been calculated that about 152 tons of dry solid matter come down in the sewage per annum, and that about 51 tons of this matter are carried on to the contact beds in the slate bed effluent. This leaves 101 tons of dry solid matter over, of which it has been shown that about 100 tons are drained on to the sludge lagoon.[*] Practically speaking, therefore, there appears to have been little digestion, *i.e.*, little diminution in solids, in the slate beds.

Capacity of Slate Beds.

The following table gives the capacity of two of the slate beds, taken as typical, at different times:—

Gallons.

	A. Empty Tank Capacity (measured).	B. Calculated Capacity of Slate Beds when new (September, 1905), *i.e.*, 88 per cent.[†] of the empty tank capacity.	C. Capacity of Slate Beds at beginning of observations (July 7th, 1909), (gauged).	Capacity of Slate Beds at end of observations (September 1st, 1910), (gauged)	Capacity on September 1st, 1910, expressed as percentage of capacity in columns :—		
					A.	B.	C.
Bed No. 3 -	53,550	47,124	42,755	40,921	76·4	86·8	95·7
Bed No. 6 -	53,550	47,124	39,120	39,039	72·9	82·8	99·8

These figures show that there was very little loss of capacity in the slate beds at Devizes after five years' working. This is what would be expected, when the amount of sludge that is drained away from the beds is taken into account.

Number of Fillings Received by the Slate Beds.

Records of the number of fillings which each slate bed received were kept over a period of 283 days (November 28th, 1909, to September 6th, 1910).

Each of the six smaller slate beds received 255–260 fillings.

Each of the two larger slate beds received 47 fillings.

For the six smaller beds, the average number of fillings per 24 hours was 0·90, *i.e.*, 1 filling every 27 hours.

Since, with a normal flow, each of these beds takes about 3 hours to fill and about 3½ hours to empty, each bed receives about 20½ hours complete rest between 2 fillings.

As the two larger slate beds are only used to treat storm water, the period of rest they receive depends on the state of the weather.

State of the Contact Beds on which the Effluent from the Slate Beds is Treated.

The beds on which the slate bed effluent is treated are filled with very fine coke breeze, much finer, we understand, than was intended by Mr. Dibdin. Most of them were in a very water-logged condition.

On September 1st, 1910, five of the beds (Nos. 3, 4, 6, 8 and 10) were filled to overflowing with 32,500 gallons of slate bed effluent.

Taking the capacity of these beds when new, as 33 per cent. of the empty tank capacity, they would originally hold 126,000 gallons.

At the date mentioned, therefore, the capacity of these five beds was only 8·6 per cent. of the original empty tank capacity, or 26 per cent. of the original water capacity. In other words the beds had lost 74 per cent. of their original water capacity.

The effluent produced from these five contact beds is a turbid foul-smelling liquid. When it leaves the beds, it passes over pasture land, of which about 50 to 60 acres are under irrigation. The effluent from the land eventually runs into a small brook at Marsh Lane Bridge, about one mile below the works.

Nuisance from Smell.

The chief nuisance from smell at the Devizes sewage works is caused by the sewage itself. This is very noticeable when refuse from the bacon factory is coming down the sewers.

The smell which arises when the detritus tanks are being emptied is also very unpleasant.

On two occasions when a slate bed was opened, no offensive odour could be detected in the bed, even when standing at the bottom of it on a hot day. In fact, it smelt no worse than an ordinary damp cellar.

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[*] In making this calculation for digestion, the specific gravity of the sludge has been taken as 1·02; a similar sample of sludge, examined in April, 1909, which contained 4·2 per cent of dry solid matter, had that specific gravity.

[†] This value, 88 per cent., is based on the gauging of a new bed at Machynlleth on September 2nd, 1909. Mr. Dibdin himself gives 87 per cent. as the water capacity of a new slate bed ("Recent Improvements in the Methods for the Biological Purification of Sewage," 1907, p. 15).

Once a slate bed was full, it gave rise to practically no nuisance from smell, but, of course, some nuisance was caused in the process of filling.

When a very strong sewage is being treated, the larger masses of the suspended solids, including fœcal matter, collect on the surface of the slates. These are swept into the beds. Although no increase of smell was noted on a good many occasions, this part of the process is one which might give rise to local nuisance.

There is, however, one circumstance in the working of the slate beds at Devizes which gives rise to a certain amount of nuisance from smell, viz., in dry weather, during the night, it takes about eight hours to fill one of the beds, which is then immediately run off; the issuing liquid always has a foul septic smell. This is no doubt due to the more prolonged stay in the slate bed.

EAST DEREHAM.

The East Dereham sewage works are situated about a quarter of a mile from the town. The sewerage is on the partially separate system, but comparatively little of the surface water finds its way to the sewers.

The average dry weather flow is about 50,000 gallons per 24 hours.

The installation consists of eight slate beds, four contact beds, and two percolating filters of the following dimensions:—

Slate Beds.

Series I.—Each about 24′ 7″ × 10′ 6″ × 3′.
Series II.—Each about 22′ 3″ × 14′ 2″ × 3′.

Contact Beds.

Each about 14′ 1″ × 46′ 8″ × 3′, filled with $\frac{1}{4}$″ to $\frac{3}{4}$″ clinker, mixed with a little $\frac{1}{4}$″ to 1″ water-worn pebbles.

Percolating Filters (Circular).

One, 308 square yards by 3′ deep.

One, 10 square yards by 3′ deep. Both of these filters were filled with $\frac{1}{4}$″ to 1″ water-worn pebbles.

There is one small grit chamber 6′ 7″ × 6′ 7″ × 3′ 4″.

Nature of Sewage.

Domestic, except for a little brewery refuse. When this refuse is arriving at the works, the flow is temporarily increased to many times the normal, but the rush lasts only about half an hour, once or twice a week, and usually occurs early in the morning when the flow is otherwise at its minimum. The result is that two slate beds are sometimes filled almost entirely with this brewery refuse.

The whole of the sewage is conveyed to the works by a 15-inch pipe, with a very slight fall.

After passing through a 1-inch screen, the sewage either enters a small grit chamber, 6 feet 7 inches square and 3 feet 4 inches deep, and then flows by gravitation into one of eight slate beds; or it flows directly on to a small piece of land about 2½ acres in extent. In time of storm, part of the sewage goes over the land, but most of it is merely screened and then passes directly into the brook. The land is not drained.

Part of the area consists of osier beds, the revenue from which has decreased about 80 per cent. since they have been used regularly. The land receives rather more than half the sewage which is treated at the works.

Description of Slate Beds.

There are two series of four slate beds each, which were installed on March 24th, 1909.

Each bed of Series I. measures about 24′ 7″ × 10′ 6″ × 3′ and has an empty tank capacity of 650 cubic feet.

Each bed of Series II. measures about 22′ 3″ × 14′ 2″ × 3′ and has an empty tank capacity of 850 cubic feet.

The beds of Series I. are discharged on to one of two percolating filters, while each bed of Series II. is discharged on to a corresponding contact bed.

Method of Working the Slate Beds.

Each bed is allowed to fill as fast as the flow of sewage permits, and is then left standing full for a fixed time, when it is drained on to a filter bed. A slate bed normally takes about an hour to fill, and as long or longer to empty. When the slate beds were new, they were allowed to stand full for two hours, this procedure being adhered to until June 30th, 1910. Since then they have been allowed to stand full only one hour.

The man in charge has to keep a careful watch on the issuing slate bed effluent, when a bed has nearly emptied itself, so as to shut the valve when black sludge begins to come away. When the beds were new, it was possible nearly to empty them without any marked discharge of solids taking place, but as time went on, it became necessary to stop the outflow sooner. In September, 1910, there was a depth of black sludge varying in the different beds from 7 to 20 inches, out of a total bed depth of about 30 inches.

This accumulation of sludge caused considerable inconvenience, as the beds had to be filled 4 or 5 inches higher than the top of the slates, in order to get enough effluent to work the syphons attached to the corresponding contact beds.

Settlement Effected by Slate Beds.

The full figures of analysis are given in Table B.

Two series of samples were taken as described in the Introductory Note above. On each occasion a number of corresponding average samples were taken of the sewage entering the slate beds and of the effluent leaving them. The samples thus taken represented the whole of the sewage treated in the beds during eleven days. The slate beds effected a reduction of about 48 per cent. in the suspended solids of the sewage, as shown by the following analyses.

DEREHAM.

TABLE B.—*Parts per* 100,000.

	Samples drawn from 7th to 14th July, 1909.				Samples drawn from 15th to 17th September, 1910.				
	No. of Analyses.	Screened Sewage.	Effluent from Slate Beds.	Percentage reduction on the Sewage.	No. of Analyses.	Screened Sewage.	Effluent from Slate Beds.	Percentage reduction on the Sewage.	Percentage reduction on the Screened Sewage, calculated on the combined samples.
Ammoniacal nitrogen - - -	8	**4·93** (3·46—6·81)	**4·80** (3·88—5·87)	2·6	3	**4·27** (3·42—5·16)	**4·46** (3·64—5·56)	—	—
Albuminoid nitrogen - - -	8	**0·95** (0·62—1·70)	**0·71** (0·56—1·12)	25·3	3	**1·03** (0·57—1·38)	**0·76** (0·52—0·88)	26·2	25·8
Total organic nitrogen - - -	8	**1·83** (0·98—5·05)	**1·53** (0·87—3·33)	16·4	3	**2·42** (1·22—3·26)	**1·91** (1·47—2·14)	21·1	18·9
Total nitrogen - - - -	8	**6·79** 5·32—8·50)	**6·33** (5·08—7·74)	6·8	3	**6·69** (5·46—8·41)	**6·37** (5·64—7·70)	4·8	6·2
Oxygen absorbed from $\frac{N}{8}$ permanganate—at once	8	**2·77** (1·58—6·52)	**2·16** (1·07—5·01)	22·7	3	**3·23** (1·58—4·25)	**2·50** (1·40—3·11)	22·6	22·4
Oxygen absorbed from $\frac{N}{8}$ permanganate—after 4 hours	8	**13·63** (5·85—33·18)	**9·86** (5·32—21·36)	27·7	3	**12·99** (6·42—16·49)	**11·47** (5·86—15·47)	11·7	23·6
Solids in suspension - - -	8	**16·1** (9·7—31·2)	**8·5** (6·0—14·3)	47·2	3	**22·6** (11·5—33·4)	**11·8** (9·4—14·1)	47·8	47·5
Volatile matter in these suspended solids	8	**11·9** (6·8—22·7)	**6·4** (4·4—10·9)	46·2	3	**16·3** (9·3—23·4)	**9·2** (8·0—10·2)	43·6	45·0
Solids by centrifuge (Vo's.) - -	8	**114·3** (60·4—262·8)	**47·1** (34·8—82·0)	58·8	3	**163·2** (70·7—247·0)	**65·6** (40·0—87·2)	59·8	59·3
Chlorine - - - - - - -	8	**11·0** (6·60—24·02)	**10·36** (6·72—20·01)	—	3	**11·01** (7·65—12·73)	**11·07** (7·78—12·85)	—	—

Arrangements for Dealing with Sludge.

There is no special provision for sludge disposal. The whole of the solid matter going into the slate beds must either stay there or pass forward to the filter beds.

Accumulation of Sludge.

This is discussed later, under "Capacity of slate beds" (*see* below).

Digestion of Sludge.

Owing to the method of construction, it was found to be practically impossible to take fair average samples of the sludge from the slate beds at East Dereham, and without such datum no estimate can be given of digestion in these slate beds.

Appearance and Condition of Slate Beds.

The slate work appeared to remain in the same condition throughout the observations, there being no sign of any breaking down of the material.

All the beds remained quite water tight. The surface of the beds was, in some cases, fairly clean, and in others, very dirty, with pieces of paper, fruit skin, and foecal matter. In order to keep the beds clean, it is necessary to sweep the tops once a week and to remove the sweepings. These are placed, together with the grit from the grit-chamber, on a heap, but the bulk is small and the smell which arises can only be noticed when in close proximity to the heap.

On looking into the inspection holes, it was observed that nearly all the slates had a black or brown deposit on them. This generally varied from a quarter to half an inch in thickness and, though sometimes brown on the surface, it was always black underneath. The deposit had a strong earthy smell and was not at all septic or putrid in character

Capacity of Slate Beds.

On July 7th, 1909, the capacity of each of the slate beds was measured. From that date until September 16th, 1910, records were kept for the Commission of the number of fillings of each bed. On September 15th and 16th, 1910, each of the slate beds was again gauged. These measurements are given in Table C.

TABLE C.

CAPACITY MEASUREMENTS OF THE SLATE BEDS.

Gallons.

No. of Bed.	A. Empty Tank Capacity (measured).	B. Capacity of Bed with the Slates in (88 per cent. of A.)*	C. Capacity on July 7th, 1909, at beginning of observations (gauged).	D. Capacity on September 15th, 1910, at end of observations (gauged).	Capacity on September 15th, 1910, expressed as percentage of the capacities in columns:—		
					A.	B.	C.
First Series.							
No. 1 - -	4058	3571	2569	2093	51·6	58·6	81·5
No. 2 - -	3871	3406	3050	2042	52·7	59·9	66·9
No. 3 - -	4083	3593	2428	1653	40·5	46·0	68·1
No. 4 - -	4096	3604	2450	2064	50·3	57·3	84·2
Mean - -	4027	3543	2624	1963	48·8	55·4	75·2
Second Series.							
No. 1 - -	5143	4526	2483	2004	39·0	44·3	80·7
No. 2 - -	5224	4597	3421	2270	43·4	49·4	66·3
No. 3 - -	5299	4663	2978	2208	41·7	47·3	74·1
No. 4 - -	5554	4887	3115	1733	31·2	35·5	55·6
Mean - -	5305	4668	2999	2054	38·8	44·1	69·2

* See footnote †, page 208.

The figures of this table show that there has been a great loss of capacity in the slate beds. This is what would be expected, seeing that as much sludge as possible is prevented from leaving the slate beds and from passing forward on to the contact beds.

The whole volume of sludge actually in the slate beds was measured indirectly by the loss of capacity of the beds. It amounted to 16,780 gallons.

Table D gives the volume of the layer of sludge at the *bottom* of each bed on September 16th, 1910.

TABLE D.

No. of Bed.	Depth of Sludge (average).	Volume of Sludge (calculated.)	
	Feet.	Cubic feet.	Gallons.
Series I :			
No. 1 - -	0·62	135·6	845·3
No. 2 - -	0·65	142·2	886·5
No. 3 - -	1·00	234·2	1,460·0
No. 4 - -	1·04	244·6	1,524·8
Total, Series I - -		756·6	4,716·6

TABLE D.—*continued.*

No. of Bed.	Depth of Sludge (average).	Volume of Sludge (calculated).	
	Feet.	Cubic feet.	Gallons.
Series II :			
No. 1 - -	1·50	415·8	2,592·1
No. 2 - -	1·08	299·4	1,866·4
No. 3 - -	1·33	368·6	2,297·8
No. 4 - -	1·66	460·1	2,868·3
Total, Series II - -		1,543·9	9,624·6
Total, Series I and II -		2,300·5	14,341·2

From this Table it is seen that there were about 14,341 gallons of sludge at the *bottom* of the eight slate beds on September 16th, 1910.* This was the result of 541 days' working, during which about fifteen million gallons of sewage were treated. In some of the slate beds the sludge was so stiff that a thick stick would stand upright in it, in others it was comparatively soft. As has already been stated, no provision has been made for removing this sludge.

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* This leaves 16,780 – 14,341 = 2,439 gallons on the upper layers of slate.

It is evident that the amount of sludge which accumulates in the slate beds depends largely on the manner in which they are worked. If they are allowed to drain empty every day, they will lose very little capacity, but the sludge will then pass on to the filter beds and cause those beds to lose capacity. In this connection it should be noted that, notwithstanding that the slate beds were so worked as to retain as much of the suspended solids as possible, the four contact beds lost 11,121 gallons of capacity (equivalent to 48 per cent. of their original water capacity) during the period of observation; and, further, that the contact beds treated only about 58 per cent. of the whole volume of slate bed effluent, the remainder being treated on the percolating filters.

Number of Fillings received by Slate Beds.

March 24th, 1909, to September 16th, 1910. 541 days.

	Bed No. 1.	Bed No. 2.	Bed No. 3.	Bed No. 4.
1st Series - -	617	547	591	584
2nd Series - -	656	658	681	641

These figures show that each bed received on an average 1·14 fillings per 24 hours.

At this rate the beds have a period of complete rest of about 17 hours per day.

Slate Bed Effluent.

Except for the smaller quantity of suspended matter which it contained, this was indistinguishable from the sewage in appearance or smell.

The Filters.

(*a*) *Percolating Filters.*—The slate beds in Series I discharge on to one of two percolating filters. The larger of these is circular and has an area of 308 square yards, and being 3 feet deep, has a capacity of 308 cubic yards. The filtering material consists of water worn pebbles varying in diameter from ¼ inch to 1 inch, laid on perforated tiles on a concreted floor. The slate bed effluent is distributed by means of a Fiddian distributor. The filter effluent appeared to be of fair quality, and the filtering material was still very clean after working continuously for about eighteen months, at the average rate of about 39 gallons per cube yard per 24 hours.

The smaller percolating filter has an area of about 10 square yards; it was used comparatively little and no observations were made respecting it.

(*b*) *Contact Beds.*—Each slate bed in Series II has its corresponding contact bed. These contact beds have each an average area of 205 square yards and an empty tank capacity of 205 cubic yards.

The filtering material consists of ¼ inch to ¾ inch clinker, mixed with a little ½ inch to 1 inch water worn pebbles.

The slate bed effluent is partially distributed over its corresponding bed by a system of earthenware half-pipes, the flow of liquor on to the beds being stopped when it begins to bring out black sludge. When full, the beds are allowed to stand for 2 hours and the filter effluent is then discharged into the brook. The effluent appeared to be of poor quality, and was brown and opalescent. A chance sample putrefied upon incubation.

At the conclusion of the period of observation, the material was found to be considerably choked at that end of a bed where most slate bed effluent enters. The other end of the bed was clean. The choked portion had a strong earthy smell when it was turned up with a spade.

The capacities of the contact beds at the beginning and at the end of the period of observation are given in Table E. From this it will be seen that the beds lost, on an average, about 48 per cent. of their original water capacity in fourteen months.

TABLE E.

CAPACITY MEASUREMENTS OF CONTACT BEDS.

Gallons.

No. of Bed.	A. Empty Tank Capacity (measured).	B. Calculated Capacity when filled with the coke (50 per cent. of A).	C. Capacity on July 7th, 1909 (estimated).*	Capacity on September 15th, 1910 (gauged).	Capacity on September 15th, 1910, given as percentages of the capacities in columns:—		
					A.	B.	C.
No. 1 - -	11,689	5,844	5,196	2,212	18·9	37·8	42·6
No. 2 - -	11,608	5,804	5,278	2,941	25·3	50·7	55·7
No. 3 - -	11,470	5,735	5,190	3,500	30·5	61·0	67·4
No. 4 - -	11,321	5,660	5,117	3,269	28·9	57·7	63·9
Mean - -	11,522	5,761	5,195	2,980	25·9	51·8	57·4

* The loss of capacity between the date of inauguration of the beds and July 7th, 1909, was taken as being proportional to the loss up to September 15th, 1910, in the ratio of the number of fillings before and after July 7th, 1909.

Nuisance from Smell.

There is a strong and very insistent earthy smell all over the works, and particularly where the slate bed effluents discharge on to their filters. When the slate bed effluent containing brewery waste is being discharged, however, the smell is decidedly offensive.

The slate beds themselves had, at the beginning of the observations, the same earthy smell as the issuing effluent, but in a lesser degree, and it could hardly be said that they gave rise to nuisance from smell. At the end of the observations, when sludge had accumulated largely in them, the earthy smell was distinctly stronger.

A strong earthy smell was noticeable about 50 to 100 yards leeward of the irrigated land.

MACHYNLLETH

Machynlleth is a small town of about 2,000 inhabitants, 10 miles distant from both Aberystwyth and Aberdovey, and situated on the south bank of the river Dovey, a river noted for its salmon and sea trout fishing.

The sewage works are about a quarter of a mile from the centre of the town. The sewerage is on the partially separate system. The district is a very wet one, the average yearly rainfall being about 60 inches. For 1908 the rainfall was 57·5 inches. In times of storm the rate of flow is greatly increased.

Gaugings of the Sewage flow were taken during August and September, 1909 :—

	Gallons.
Approximate dry weather flow per 24 hours—average of 13 dry days - -	41,300
Highest dry weather flow - - -	57,300
Lowest dry weather flow - - -	20,920
Two wet days' flow -	60,950 and 71,980

For the year ending March 31st, 1910, the number of water closets was 251, and the number of baths, 54.

The town is drained by two main sewers, one coming from the higher part of the town and the other from the lower. The former carries about four-fifths of the total flow, though during the six months ending September, 1910, the flow in the lower sewer had increased considerably, probably from the influx of subsoil water.

The installation consists of :—

2 settling tanks, each 9′ 9″ × 5′ × 9′ 3″ deep.

2 slate beds, each 23′ 10″ × 14′ 4″ × 3′ 4″ deep.

2 slate beds, each 23′ 10″ × 15′ 3″ × 3′ 4″ deep.

1 circular tank for storing the low level sewage—25′ 6″ diameter by 12′ deep, with an overflow pipe 2′ 6″ from the top.

4 octagonal percolating filters, each 44′ diameter by 4′ 6″ deep, worked with Adams' sprinklers.

Total area of filters—713 square yards.

Total cubic content of filters—1070 cubic yards.

The filtering material consists of a slaty gravel, which is dug up from under the subsoil. It is graded in the filters as follows :—

Top 3′ 6″ — $\frac{1}{4}$″ to 2″ diameter.

Bottom 1′ — 2″ to 3″ diameter.

The low level sewage is screened and run into the circular tank, from which it is pumped to the high level every morning (see below).

Method of Working the Slate Beds.

The sewage, which consists of the crude unscreened sewage from the high level sewer mixed with the settled sewage from the low level sewer, passes through one of the settling tanks before running on to the slate beds.

When full, the slate beds are allowed to remain so for about 2 hours, and are then discharged into a shallow reservoir, connected to a syphon chamber which feeds the sprinklers. The slate beds are emptied completely, the result of this being that a considerable amount of black solid matter gets swept out into the above channel and reservoir.

During the night the high level sewage is run into three of the slate beds, and when these become full they overflow by a sill into the syphon reservoir and so straight on to the filters.

The beds are run off as usual when the man in charge of the works arrives in the morning.

The following figures of analysis (Table F) were obtained for the average samples drawn during the two longer visits :—

MACHYNLLETH.

TABLE F.—*Parts per 100,000.*

	Samples drawn from 12th to 18th September, 1909.					Samples drawn from 20th to 22nd September, 1910.					Percentage reduction on the Settled Sewage, *i.e.*, reduction due to treatment in Slate Beds (calculated on the combined samples).
	No. of Analyses.	Crude Sewage.	Settled Sewage.	Effluent from Slate Beds.	Percentage reduction on the Settled Sewage.	No. of Analyses.	Crude Sewage.	Settled Sewage.	Effluent from Slate Beds.	Percentage reduction on the Settled Sewage.	
Ammoniacal nitrogen - -	7	**4·31** (2·22—6·80)	**3·80** (1·96—6·20)	**3·50** (1·88—4·96)	8·0	3	**2·89** (2·58—3·24)	**2·96** (2·82—3·40)	**2·90** (2·66—3·24)	2·0	6·2
Albuminoid nitrogen - . - -	7	**0·68** (0·40—0·68)	**0·64** (0·39—1·15)	**0·66** (0·37—1·18)	—	3	**0·58** (0·49—0·73)	**0·63** (0·49—0·72)	**0·60** (0·43—0·88)	4·8	0·0
Total organic nitrogen - -	6	**1·16** (0·62—1·70)	**1·00** (0·62—1·74)	—	—	3	**1·21** (1·13—1·31)	**1·21** (0·99—1·40)	**1·11** (1·04—1·23)	8.3	—
Total nitrogen - - - - -	7	**5·56** (2·84—8·36)	**4·87** (2·70—7·47)	**4·49** (2·15—6·77)	8·2	3	**4·10** (3·89—4·43)	**4·17** (3·81—4·48)	**4·00** (3·84—4·28)	4·1	6·7
Oxygen absorbed from $\frac{N}{8}$ permanganate—at once	7	**1·44** (0·67—2·11)	**1·14** (0·77—1·77)	**1·17** (0·67—1·60)	—	3	**1·41** (1·31—1·51)	**1·58** (1·12—1·37)	**1·22** (0·97—1·31)	22·8	11·5
Oxygen absorbed from $\frac{N}{8}$ permanganate—after 4 hours	7	**5·46** (3·71—7·44)	**4·74** (2·80—6·75)	**4·15** (2·34—5·37)	12·6	3	**5·27** (3·95—6·73)	**4·83** (4·12—5·84)	**3·74** (3·47—3·88)	22·6	15·6
Solids in suspension - - -	7	**9·2** (5·6—16·3)	**7·6** (5·3—13·2)	**5·4** (4·2—6·6)	28·8*	3	**13·2** (10·9—16·0)	**10·2** (7·9—12·4)	**7·7** (7·2—8·1)	25·1*	27·4
Volatile matter in these suspended solids	7	**6·6** (4·2—11·0)	**5·5** (3·4—9·4)	**4·1** (3·0—5·0)	26·6	3	**10·0** (7·6—12·0)	**7·9** (6·1—9·4)	**5·8** (5·4—6·8)	25·4	26·2
Solids by centrifuge (vols.) - -	7	**61·6** (28·8—124·0)	**47·3** (22·3—78·6)	**30·3** (15·2—40·6)	35·9	3	**76·2** (49·6—100·4)	**63·8** (41·2—87·2)	**39·4** (29·7—48·6)	38·3	36·7
Chlorine - - - - - -	7	**6·69** (3·83—8·46)	**6·06** (3·57—7·64)	**5·92** (3·37—7·39)	—	3	**5·86** (4·90—7·47)	**5·18** (5·00—6·42)	**5·41** (5·11—6·12)	—	—

* *Note.*—The percentage reduction of suspended matter, calculated on the crude sewage, amounts to 41·3, of which 19·1 is due to subsidence in the settling tanks.

Settlement Effected by the Slate Beds.

It will be noticed that the percentage reduction of suspended solids by this treatment is small, viz., 27·4. This is no doubt due (1) to the actual amount of suspended solids in the settled sewage being small; and (2) to the relatively large amount of solids which are carried out of the slate beds by their being completely emptied.

Accumulation of Sludge.

There was in September, 1910, a considerable accumulation of sludge at Machynlleth, but it was found impossible to estimate its quantity. The greater part of it consisted of the sludge from the settling tanks and the low level sewage pit, but it also included the black deposit from the slate beds which collects in the shallow reservoir.

The sludge from the settling tanks is drained into a pit, from which it is lifted by a chain pump and deposited on a heap in a field. The sludge from the low level sewage pit is removed by pail and cart on to the same heap.

When the sludge has become fairly dry, it is mixed with waste lime from the gas works and removed from time to time by a farmer, who spreads it over pasture land.

The low level sewage pit is cleaned out about every two months.

With regard to the subsequent treatment of the slate bed effluent, containing as it does, 6 parts of suspended solids per 100,000, this flows over a 6-foot weir into the reservoir already mentioned. In front of the weir a scum-board is fixed, to prevent as far as possible any floating matter getting on to the filters. Before this board was fixed, the sprinklers were continually clogging and they needed constant attention. Now they only require cleaning once a day.

The sludge which collects in the channel and reservoir is cleaned out when necessary.

From August 1st, 1909, to September 20th, 1910, this sludge was collected in two trenches, for the purpose of arriving at an estimate of its amount.

From August 1st, 1909, to January 31st, 1910, the accumulation of sludge in the first trench amounted to 2 tons 2 cwt. It contained 28·1 per cent. of dry solid matter.

From February 1st to September 20th, 1910, the sludge in the second trench measured 45 feet by 3 feet, and its average depth was 2 feet 2 inches. This sludge was found to contain 21·4 per cent. of dry solid matter, and its specific gravity was 1·17.

From these data it has been calculated that this second trench held about 9·6 tons of wet sludge.

Therefore, from August 1st, 1909, to September 20th, 1910 (13½ months), the accumulation of sludge from the slate beds amounted to about 11·5 tons (containing about 22 per cent. of dry solid matter).

The deposit on the slates averaged about half an inch in depth. There was practically none at the bottom of the beds.

Digestion of Sludge in the Slate Beds.

The method of working the slate beds at Machynlleth precludes any attempt being made to estimate the digestion of sludge in the beds.

Capacity of Slate Beds.

Owing to the foundations of beds Nos. 1 and 2 having settled, they were leaking at the time of our visit in September, 1910. Measurements of capacity can, therefore, only be given for beds Nos. 3 and 4:—

TABLE G.

Gallons.

	A. Empty Tank Capacity (Measured).	B. Calculated Capacity of Slate Beds when new (September 1908), *i.e.*, 88 per cent. of empty tank capacity.	C. Capacity of Slate Beds at beginning of observations, July, 1909 (Gauged).	Capacity of Slate Beds at end of observations, September, 1910 (Gauged).	Capacity on September 1st, 1910, expressed as percentage of capacity in columns :—		
					A.	B.	C.
Bed No. 3 -	5,490	4,831	4,165	4,447	81·0	92·1	106·8
Bed No. 4 -	5,027	4,424	3,794	3,896	77·5	88·1	102·6

These figures show that there was very little loss of capacity in the slate beds at Machynlleth after two years' working. As the beds are completely emptied after each filling, this is what would be expected.

Number of Fillings Received by Slate Beds.

Records of the number of fillings each slate bed received were kept over a period of 276 days (November 21st, 1909, to August 26th, 1910).

No. 1 slate bed received 772 fillings = 2·8 fillings per 24 hours.

No. 2 slate bed received 786 fillings = 2·8 fillings per 24 hours.

No. 3 slate bed received 807 fillings = 2·9 fillings per 24 hours.

No. 4 slate bed received 806 fillings = 2·9 fillings per 24 hours.

If sewage is being pumped from the low level sewage pit, it takes about one hour to fill each of the beds. If only the high level sewage is being treated, it takes about 3 hours.

The beds each take from forty-five minutes to one hour to empty completely.

State of Filters on which the Effluent from the Slate Beds is Treated.

Two of the four percolating filters are worked for a week and then rested while the other two are being used.

The rate of filtration in dry weather is equivalent to about 38·6 gallons per cube yard per 24 hours.

The surface of the filters was perfectly clean at the time of the last visit. No signs of growths or ponding could be seen. The effluent obtained from the filters is a fairly good one.

Nuisance from Smell.

The slate beds at Machynlleth caused no nuisance from smell whatever.

The settling tanks and the low level sewage pit smell at times, especially when the solid matter rises to the surface.

There was no nuisance from smell caused by the sludge at the time of the last visit.

A. C. CARTER.
A F GIRVAN.

January, 1911.

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